AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

No. 890.

THE ECONOMIC DIMENSIONS FOR A WATER WAY FROM THE GREAT LAKES TO THE ATLANTIC.

By GEORGE Y. WISNER, M. Am. Soc. C. E.

PRESENTED NOVEMBER 7TH, 1900.

WITH DISCUSSION.*

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cannot be stated until the surveys now being made under the direction of the State Engineer are completed, it is safe to say that the estimate made by the New York State Committee on Canals will not be changed sufficiently to materially affect the present discussion.

In previous discussions of the proposed waterway from the Lakes to the seaboard the depth of channel has been made the important factor and but little consideration given to the economy in transportation rates due to the different speeds which may be maintained by steamers in waterways of different dimensions.

For instance, in Major Symons' able report on a Ship Canal from the Great Lakes to the sea it is estimated that lake freighters of 16 ft. and 20 ft. draft would make only four miles per hour in a waterway 24 ft. deep, and that the time required at terminal ports would be from 11 to 12 days, or about the same as the sailing time of round trip; while in a barge canal 12 ft. deep, with a cross-section of 1 200 sq. ft., steam canal boats with three to five consorts in tow would be able to make practically the same number of round trips per season.

To anyone familiar with the speeds maintained by steamships in the artificial channels of our lake waterways, and with the rapidity with which cargoes are loaded and discharged at terminal ports, it seems like begging the question to draw conclusions from transportation rates based on such assumptions.

The St. Clair Flats Canal is 7 200 ft. long, 20 ft. deep at mean stage of Lake St. Clair, and has a cross-section of about 5 700 sq. ft., or 200 sq. ft. greater than the cross-section of the proposed 21-ft. waterway from the Lakes to the Atlantic for which plans and estimates have recently been made.

It has been found from actual observations that the large freighters on the Lakes can safely navigate the canal at speeds of from 7 to 11 miles per hour without slackening speed when passing other steamers in the waterway.

There is an average current of about 1.7 miles per hour in the canal, which makes navigation much more dangerous than it would be in a canal with no current except that required for the necessary water supply, yet no serious accident has ever occurred in the waterway.

Lake freighters, capable of steaming 12.5 statute miles per hour in the open lake, make from 23 to 24 round trips per season between Duluth and Buffalo, or an average of one round trip every ten days, three days

of which are due to time consumed in loading, unloading, coaling and making repairs at terminal ports.

If the detentions at the terminals of a ship canal between the lakes and New York should amount to ten or twelve days per round trip, it is safe to say that but little freight would be discharged at New York except that consigned directly to the city, a condition which would unquestionably develop methods of handling cargoes such that the detentions need be but little greater than at lake ports.

The Suez Canal had a cross-section of 3 700 sq. ft., previous to the enlargement now being made, through which the speed for large steamers was restricted to 6.2 statute miles per hour.

In the Amsterdam Canal, with a cross-section of 4 000 sq. ft., the speed is limited to 5.6 miles per hour.

In the Kiel Canal, having a cross-section of 4 100 sq. ft., a speed of 6.2 miles per hour is allowed, but the larger ships only average about 5 miles per hour.

Speeds of 6 miles per hour are allowed for large ships in the Manchester Canal, where the cross-section is 4 400 sq. ft., but, owing to the sharp curves in the canal, tugs are used for towing the larger steamers.

The limit of speed for these canals has been fixed with reference to preventing injury to the banks, but is not very different from the economical speeds which could be maintained by large steamers in waterways of such dimensions.

The retardation of the speed of a ship in a restricted waterway is due to the resistance of the sides and bottom of the channel to the movement of the water displaced by the steamer, to the velocity of the back flow of the displaced water, and to the back pressure of the water piled up in the channel in front of the moving ship.

It has been found from actual observations of the speeds of steamers on the Great Lakes that a ship capable of averaging 12.5 miles per hour in the deep water of the open lakes is retarded about 16%, or 2 miles per hour, when steaming with the same boiler pressure and only 2 ft. of water under the keel.

When the lake channels are improved so as to allow the passage of ships of 19 to 20 ft. draft, the cross-section of the St. Clair Flats Canal will be about six times that of a loaded freighter, and the mean back flow due to the movement of the ship will be about one-fifth of

the speed of the steamer. It is apparent, therefore, that where the cross-section of the waterway is less than six times that of the passing ship the speed will be retarded at least one-third of that which could be maintained in open water.

The dimensions which should be given to a waterway between the Lakes and the Atlantic depend upon the economic depth which can be obtained and maintained in the water routes to be connected.

The depth of channels at the entrances of lake harbors before improvement was only about 3 to 10 ft., and across the shallows of the connecting waterways about 9 to 13 ft.

The project of improvement now being carried out contemplates channel depths of about 21 ft. for mean lake stage, but as yet only about 18 ft. has been secured. The question to be settled is, what is the depth which can be economically given these channels such that ships able to safely weather the lake storms may be passed at all times, and that the fixed charges for maintenance and interest on cost shall not exceed the benefits to be derived from the reduction in rates of transportation and from developing new industries and commerce?

During the heavy storms which are of frequent occurrence in the fall of the year on the Lakes, large freighters drawing less than 17 ft. when loaded, have not been found well adapted for safe navigation, which fixes the minimum limit of depth of channels at about 20 ft.

For greater depth of channels than 20 ft. the advisability of improvement will depend upon whether the benefits to be derived will be equivalent to the fixed charges arising from maintenance and cost of construction.

At the head of Lake Erie, through Lake St. Clair, and at the foot of Lake Huron and Lake Superior there are extensive flats where the water is only about 21 ft. deep at average stage, and if the connecting channels should be made a greater depth, nearly 60 miles of the route through the rivers and lakes would be excavated channel.

The cost to the Government to deepen the lake channels for depths of over 21 ft. will be about $3 000 000 per foot, and to improve the lake harbors and entrances correspondingly will cost about $4 000 000 per foot, or a total of $7 000 000 for each additional foot of depth in harbors and waterways. Assuming that the Government pays 3% for the money expended on improvements and one-half of 1% for maintenance,

the annual fixed charges for each additional foot of depth would be approximately $245 000.

The actual freight carried on the Lakes in 1899 was not far from 40 000 000 tons, and if the annual fixed charges arising from making and maintaining deeper waterways should be chargeable to the entire amount of traffic, the saving in transportation rates would have to exceed six mills per ton for each foot of improvement to make the accounts balance.

The actual saving in the cost of transportation on the Lakes by using deeper draft vessels is only about one-half the above estimated fixed charges, and therefore the improvement would be advisable only on the supposition that the indirect benefits from developing new industries and new commerce will be of greater value to the country than the total decrease in the cost of transportation. This could hardly hold true as the decrease in rates would be permanent, while the effect of the improvement in developing new commerce would likely be of only a few years' duration.

It is true that the fixed charges arising from interest on the cost of waterway improvements and from expense for operation and maintenance are paid by the Government, but whether paid from Government revenues or from toll on traffic the net result is the same, and should be considered in the comparison of transportation rates, especially with those on railroads where such expenses are paid directly from the earnings.

If we take into consideration the fact that ships of more than 500 ft. length cannot be safely handled in the sharp curves of the connecting waterways of the Lakes, that with a draft of 18 to 19 ft., ships not exceeding such length can safely navigate the Lakes at all seasons, and that for greater depths of channels than 21 ft. the interest and maintenance account will exceed any expected returns from lower transportation rates, there seems to be no legitimate reason why the ultimate depth for lake waterways should not be definitely settled at once.

While it is true that the small freighters of the Lakes must go out of business and make way for the more economical type carrier, it is also true that a continual change of dimensions of waterways renders the smaller ships practically obsolete long before worn out, and since the rate at which freight can be carried depends upon the probable

useful life of the ships, continual changes in the type of freight carriers will materially increase the cost of transportation.

If the freight business on the Lakes can be conducted as economically with waterways 21 ft. deep as with channels of greater depth, the waterway from the Lakes to the Atlantic should not exceed such depth unless it can be shown that the benefits to be derived from through transportation between the Lakes and foreign ports in deep draft ships will be of sufficient importance to warrant the larger expenditure required to construct a canal of corresponding dimensions.

Tables Nos. 1 and 2 give the details of the length of channels of different dimensions, the amount of lockage, and the estimated cost of waterways 21 ft. and 30 ft. deep from Buffalo to New York *via* the Oswego-Mohawk and St. Lawrence-Champlain routes, and are abstracted from the report of Board of Engineers on Deep Waterways.

TABLE No. 1.—BUFFALO TO NEW YORK.

	*OSWEGO-MOHAWK ROUTE.		CHAMPLAIN ROUTE.
	High-level plan.	Low-level plan.	
Total distance, miles	477.04	476.94	685.21
Fall, regulated stage of Lake Erie to mean tide, feet	574.5	574.5	574.5
Down lockage, feet	742.6	705.6	547.2
Up " "	170.6	133.6	0.0
Total lockage, "	913.2	839.2	547.2
Number of locks	39	37	19
" " guard locks	1	1	2
Standard canal, miles	102.56	102.42	102.35
Canalized river—			
200 to 250 ft. bottom width, miles	.....	.....	1.51
250 to 300 " " "	20.38	20.38	.....
300 to 350 " " "	12.37	12.37	38.97
350 to 400 " " "	2.59	2.59	.....
400 to 450 " " "	13.90	13.90	8.08
450 to 500 " " "	8.99	8.99	11.59
500 to 1 000 " " "	39.15	37.65	73.65
Open lake and river	277.10	278.64	449.06
Total.....Miles	477.04	476.94	685.21

*Note: In the high-level plan for the Oswego-Mohawk Route the water supply is to be obtained from reservoirs in the Black and Salmon River Valleys, and in the low-level plan Oneida Lake is to be used as a reservoir, with a deep cut for the waterway between Oneida Lake and the Mohawk River.

TABLE No. 2—Estimated Cost of Waterways.

	30-Ft. Channel.	21-Ft. Channel.
Lake Superior to Lake Erie.....	$33 539 869	$6 961 818
Lake Michigan to Lake Erie.....	16 226 548	1 466 439
Lake Erie to Lake Ontario.....	73 435 350	42 393 203
Lake Ontario to New York—		
Oswego-Mohawk Route (High-Level Plan).....	206 253 553	155 324 968
Oswego-Mohawk Route (Low-Level Plan).....	210 309 129	157 003 082
St. Lawrence-Champlain Route.	213 123 864	141 027 415
Duluth to New York—		
Oswego-Mohawk Route (High-Level Plan).....	313 228 772	204 679 989
Oswego-Mohawk Route (Low-Level Plan).....	317 284 348	206 358 103
St. Lawrence-Champlain Route.	320 099 083	190 382 436
Chicago to New York—		
Oswego-Mohawk (High Level-Plan).....	295 915 451	199 184 610
Oswego-Mohawk (Low Level-Plan).....	299 971 027	200 862 724
St. Lawrence-Champlain Route.	302 785 762	184 887 057

The Committee on Canals of New York State, in its report to the Governor of New York, estimate that a barge canal from Buffalo to the Hudson River, 351 miles long, 12 ft. deep, with a cross-section of 1 200 sq. ft. will cost $58 894 668.

The Canadian government has expended about $65 000 000 upon the construction and maintenance of the St. Marys, Niagara and St. Lawrence canals, or about $13 per capita for the entire population of the country. This amount, however, does not represent the cost to construct the canal system as now completed, as nearly the entire system on the Niagara and St. Lawrence Rivers has been enlarged from two to three times. The canals are 14 ft. deep, with locks 270 ft. long and 45 ft. wide, and were intended to develop through transportation between the Lakes and Montreal.

The expectations relative to the volume of traffic that would be

developed have not been realized, and it is extremely improbable that the small type of steamer which can pass the locks will be able to compete with the large lake freight carriers, even when handicapped with excessive transfer charges at Buffalo.

It will be noted that the length of standard canal is practically the same by the Mohawk or Champlain routes, and that the 208 miles greater distance by the latter route is mostly through the wide channel of the Lakes and rivers.

The Champlain route is a down-grade waterway from the Lakes to the seaboard, and has 366 ft. less lockage than the Mohawk high-level route, and for a 21-ft. channel will cost $14 300 000 less than the latter.

It is fair to assume that in a 21-ft. waterway with an area of cross-section practically the same as the St. Clair Flats Canal, the speed of ships in straight reaches will be fully as great as that of the larger lake freighters in the St. Clair Canal. Making the necessary reductions for slower speed on curves and in passing ships *en route*, and for detentions at locks, it is found that a freighter capable of steaming 12.5 miles per hour in the open lake should make the round trip between Chicago and New York in 11 days and 8 hours *via* the Mohawk Route, and in 12 days and 9 hours *via* the Champlain route.

The navigation season on the Mohawk route will average about 245 days and for the Champlain route 230 days, and if the detention at New York is not more than twice the time required at Buffalo, a lake steamer should make 16 round trips per season between Chicago and New York *via* the Mohawk route and fourteen by the Champlain route. The average sailing time between Chicago and Buffalo for steamers capable of running 12.5 miles per hour in the open lake is about 72 hours, and the estimated time for the same type of steamers between Buffalo and New York based on the actual performance of freighters in similar restricted channels of the lake waterways is 64 hours.

This estimate is based on a 21-ft. waterway having a cross-section of 5 500 sq. ft. area or about six times the midship section of ship, which ratio will allow safe speeds of 8 to 10 miles per hour with the same consumption of fuel required in open water.

In the previous discussion* the Ship Canal is assumed to be 24 ft. deep, with a section of 4 200 sq. ft., and that ships having midship

* *Transactions*, Am. Soc. C. E., Vol. xxxix.

sections of 1 000 sq. ft. would average about 4 miles per hour, not including detentions at locks and terminals.

In the case of the barge canal the proposed cross-section is 1 200 sq. ft. or four times that of the barge, a ratio which will not admit of average speeds of over 4 miles per hour with ordinary barge fleets.

From these elements it was estimated that steamers in the ship canal, and barge fleets in the barge canal, will only average ten round trips per season between Buffalo and New York, whereas with suitable dimensions for the waterway and proper dispatch in loading and discharging ships at terminals at least 14 to 16 round trips may be made between Chicago and New York, or about three times the annual volume of business estimated in the 1898 discussion for steamers on the ship canal from Buffalo to New York.

The expense account of lake and ocean freighters is so much greater than that for canal barges that an accurate estimate of practical speed in canals and of detentions at terminals is essential in making any comparison of rates at which freight can be carried on the two types of waterways.

In the report of the Committee on Canals of New York State, it is estimated that a ton of freight can be transported from Buffalo to New York on barges for 26 cents, but in obtaining such a result the Committee omits from the expense account the items for interest on cost of construction, annual expenses for repairs and maintenance, and profit for the shipowner.

The interest and insurance expenses are based on a valuation of $28 500 for a fleet of one steamer and three barges, yet in a foot-note on page 19 of the report it is shown that if constructed of steel the fleet would cost $70 000.

With the increase in the cost of lumber which is sure to occur in the near future, the cost of barges constructed of wood will approximate that of steel; but even if this should not be the case, it is probable that the greater cost of towing wooden barges would make the steel barge more economical for transportation at the values given.

At the Brussels International Congress on Navigation in 1898, Captain C. V. Suppan, Chief of the Steam Navigation Service on the Danube, gave the result of some experiments in towing steel and wooden barges of similar models on the Danube, from which it appears that the power required for the wooden barges was nearly twice that required

for the steel barges, and that the cost for towing per ton-mile for the wooden barge was about double that for the steel.

If these results are correct, the wooden barge will not be economical, even at a lower value than that given in report.

Correcting the estimate on page 64 of the Report of the Committee on Canals for omissions and for change in values, the expense account for barge fleet, with a total annual traffic on canal of 15 000 000 tons, will be as follows:

TABLE No. 3.—EXPENSE ACCOUNT, BARGE FLEETS.

Wages and subsistence	$4 000
Fuel, oil, waste, etc	3 300
Ordinary repairs	300
Insurance on fleet, 4½ per cent	3 150
Insurance on cargo	3 900
Miscellaneous expenses	200
Interest on investment, 5 per cent	3 500
Deterioration, etc., 5 per cent	3 500
Fixed charges for maintenance, repairs and interest on cost of canal (3 per cent.)	8 800
Shore expenses and commissions	1 000
Profit to ship-owner	1 500
Total for 52 000 tons	$33 150
Cost of transportation per ton between Buffalo and New York	0.64
Rate on lake, Chicago to Buffalo	0.50
Transfer at Buffalo	0.25
Total rate per ton, Chicago to New York	$1.39
" " bushel, " "	0.042

The rate per ton for both the barge and the ship canal (Tables Nos. 3 and 4) will vary from these estimates with any variation of the volume of traffic from that used. West-bound freight, which has been estimated at one-third of the eastward movement and at the same rate per ton, would, under normal conditions, command a higher rate than the east-bound freight, but with the volume of westward traffic only sufficient for one-third cargoes for the ships in the service, competition would be

TABLE No. 4.—Dimensions, Capacity and Expenses of a Steamship Adapted for the Traffic of a 21-Ft. Waterway, and Capable of Running 12.5 Miles per Hour in the Open Lake.

Length over all	480 ft.
Breadth	52 "
Draft	19 "
Horse-power, (I. H. P)	2 200
Coal consumed per hour	3 850 lbs.
Net carrying capacity	8 600 tons
Cost of ship for lake and canal business only	$360 000
Cost of ship adapted for ocean and lake business	387 000
Pay-roll and subsistence, per day	60
Fuel, oil and waste, per day, when running	117
Fuel, oil and waste, per day, in port	30
Insurance	4½%
Repairs and depreciation	5%
Expenses for season of 245 days:	
Wages and subsistence	$14 700
Fuel, oil, waste, etc	23 400
Insurance on ship	16 200
Insurance on cargo	22 900
Miscellaneous expenses	1 000
Interest on investment, 5 per cent	18 000
Deterioration, etc., 5 per cent	18 000
Fixed charges for maintenance of canal, repairs and interest on cost (3 per cent.)	73 400
Shore expenses and commissions	2 000
Profit to ship owner	10 000
Total for 183 470 tons	$199 600
Rate per ton, Chicago to New York	$1.09
Rate per bushel, Chicago to New York	0.033

likely to force the rate fully as low as for east-bound traffic. The interest on the cost of the canal during construction would also increase the amount of fixed charges above those used in the estimates, and correspondingly increase the rate per ton.

These variations will have relatively the same effect on the rates for both the barge and ship canal, and therefore would not materially change the comparative value of the two types of waterways.

The items from Tables Nos. 3 and 4, for wages, subsistence, fuel and miscellaneous expenses, amount to between one-fourth and one-fifth of the respective total expense accounts, showing that the actual cost of moving a ton of freight from Chicago to New York will be less than one-fourth of the rate necessary to transact the business, and therefore any material reduction in transportation rates can only be obtained by constructing waterways on which quick trips can be made and all unnecessary transfer and terminal charges eliminated.

The comparative transportation rates given in Major Symons' report differ from the present estimate for the reason that the latter includes fixed charges for maintenance and interest, and is based upon speeds in the restricted portions of the waterway which have been demonstrated to be safe and practical in the connecting channels of the Lakes, and upon dispatch at terminal ports similar to that now obtained at Lake harbors.

The average time in port for freighters running between Duluth and Buffalo is about three days per round trip, but to make allowance for the different conditions in New York Harbor four days per round trip have been used in the present estimate.

It is also assumed that if the volume of traffic on the barge canal should amount to 15 000 000 tons annually, a ship canal of dimensions suitable to allow the lake tonnage free passage to the seaboard would develop at least 20 000 000 tons per year.

The record of the transportation rates and volume of traffic on canal and railroads between Buffalo and New York indicate that any waterway which does not admit of steamers passing direct between lake ports and the seaboard is not likely to prove a successful competitor of the railroads.

The freight carried on the Erie Canal:

In 1837 was	667 151	tons.
In 1850 "	1 635 089	"
In 1860 "	2 253 533	"
In 1870 "	3 083 132	"
In 1880 "	4 608 651	"
In 1890 "	3 303 929	"
In 1899 "	2 414 084	"

Since 1880, when the traffic on the Erie Canal reached a maximum, the rate per ton-mile on the railroads from the Lakes to the seaboard has been nearly double that on the Erie Canal, yet during that time the business of the canal has diminished one-half, while that on the railroad has nearly trebled, showing beyond question that the volume of freight which will be shipped by any given route does not depend entirely upon the relative transportation rates, and that unless the causes which have produced the decline of traffic on the Erie Canal are eliminated in the construction of new waterways no better results need be expected.

Two of the principal benefits to be expected from the construction of a waterway of proper dimensions between the Lakes and the Atlantic, are the development of ship-building industries at lake ports, and to make it possible for individual ship owners to do business in competition with combinations, neither of which could be realized from the construction of a 12-ft. barge canal.

The only possible way in which the traffic of a barge canal requiring transfer of freight at Buffalo can be increased over that of the present Erie Canal, will be by organizing large transportation companies to operate fleets of barges in connection with freight steamers on the Lakes, so that through bills of lading can be made from lake ports to the seaboard.

Such an arrangement would also require the control of sufficient elevator capacity at Buffalo to take care of the surplus grain which at times would be greatly in excess of the carrying capacity of the barges.

With economical water transportation only possible for organizations controlling large amounts of capital, it is by no means improbable that the canal and railroad companies would combine to maintain rates, and thereby destroy about the only benefit to be expected from a canal of such dimensions.

In a waterway having dimensions to correspond with the depth of the water routes connected, individual ship owners would have equal opportunities with the large organizations and practically make the control of freight rates impossible.

Such a waterway would also make it possible to increase largely the steel and shipbuilding industries of the country, and probably be of great assistance in restoring the Merchant Marine of the United States in foreign trade.

It is of interest to note that the distance from Buffalo to New York by railroad is 440 miles, by Barge Canal 496 miles, and by ship canal *via* Lake Ontario and the Mohawk River is 477 miles, making the barge route 19 miles longer than the ship canal, with about three times greater amount of canal section through which boats will have to move at minimum speed.

Referring to the estimated cost of 21 and 30-ft. waterways from the Lakes to the seaboard it will be noted that the latter will cost about $100 000 000 more than the former, not including the cost of improving terminal harbors. The difference in expense for operation, maintenance and repairs will be about $550 000 per year, making the fixed charges for a 30-ft. waterway, including the improvement and maintenance of lake harbors, nearly $5 000 000 greater than for one of 21-ft. depth.

It has been shown that taking the cost of improvements into consideration the commerce of the Lakes can be transported more economically with channels of 21-ft. depth than with deeper ones, and therefore whatever advantages are to be derived from a 30-ft. waterway from the Lakes to the Atlantic must come from developing new industries and commerce by direct trade between the Lakes and foreign ports.

With a traffic of 20 000 000 tons annually in such a waterway it is not probable that more than 6 000 000 tons would be foreign commerce, and if carried in deep-draft vessels the 14 000 000 tons for domestic consumption would have to be discharged at New York for use in the city, or for reshipping to other ports on the Atlantic Coast. This would necessitate two-thirds of the ships trading direct between the lake ports and New York, or sailing for Europe with light loads.

With a 21-ft. waterway the ships adapted to the service could discharge domestic commerce at New York or at any other port on the coast to which consigned, but would probably transfer all foreign freight to ocean steamers at New York, except on the last trips before the close of lake navigation, when it might be found advantageous to load for through passage to Europe.

Taking into consideration the annual expenses for interest and maintenance of the two waterways, the cost of transportation for domestic traffic will be 6 cents per ton greater for a 30-ft. waterway than for one 21 ft. deep, from which it would appear that any benefits

to be derived from canals of greater depths than necessary for economical transportation on the Lakes must result from direct foreign trade between the lake ports and Europe.

If the difference of the annual fixed charges for the two depths of waterway between Buffalo and New York be charged to the probable volume of foreign traffic, the transportation rate will be about 20 cents per ton greater with a 30-ft. waterway than with a 21-ft. canal.

The amount of transfers at New York for the combined domestic and foreign traffic would be fully as great when transported in deep-draft ships as when carried in steamers adapted for safe navigation of the lake waterways, and therefore the benefits to be expected for the deeper waterway must be wholly of an indirect nature.

Since the interests of the steel and ship-building industries would be equally well subserved by either waterway, it is difficult to conceive of conditions which would warrant the large expenditure necessary to construct a waterway of greater dimension than required for safe and economical navigation on the Lakes.

Almost any transportation rate may be deduced for the routes of different depths, by varying the assumed speed in the restricted channels and the time lost by detentions at terminal ports. If, however, the dimensions of channels be such as to allow economical speeds for the type of vessel adapted to their use, there need be no trouble in establishing these elements of the problem within reasonable limits, as the average speed at which canal barges can be towed is pretty well known, and the safe speeds of steam ships in the restricted waterways of the Great Lakes and in the Ship Canals of Europe furnish data from which the ratio of cross-section of channel to that of ship may be determined, which will give a minimum rate of transportation.

Conclusions.

1. A waterway from the Great Lakes to the Atlantic, to produce the best results, should have dimensions which will permit the passage, at economical speeds, of ships best adapted for the traffic of the water routes connected.

2. Safe navigation of the Great Lakes requires a minimum depth for the connecting channels of at least 20 ft. and for depths of over 21 ft. the interest on the cost of construction will exceed the decrease in transportation rates due to the use of deeper draft freight carriers.

3. With any waterway requiring the transfer of freight at Buffalo, independent canal boats cannot compete with existing lake and railroad lines, and, unless the waterway is operated by rich transportation companies controlling lines of lake steamers and canal barges, the business developed will probably not exceed that of the present Erie Canal.

4. The decline of traffic on the Erie Canal since 1880, and the failure of the 14-ft. Canadian canals to divert commerce from the lake and railroad lines, indicate that a waterway of less depth than required for the passage of the best type of lake freighters cannot materially modify the transportation rates over existing routes.

5. The indirect benefits to commerce to be derived from a 21-ft. waterway will be nearly as great as can be expected with greater depth of channel.

DISCUSSION.

Mr. Symons.

THOMAS W. SYMONS, M. Am. Soc. C. E. (by letter).—Without entering upon a discussion of the general canal proposition, the writer feels compelled to take exception to some of the statements in Mr. Wisner's valuable paper, and particularly wishes to dissent from his fourth conclusion, which is as follows:

"The decline of traffic on the Erie Canal since 1880, and the failure of the 14-ft. Canadian canals to divert commerce from the lake and railroad lines, indicate that a waterway of less depth than required for the passage of the best type of lake freighters cannot materially modify the transportation rates over existing routes."

The decline of traffic on the Erie Canal is due to very many causes, the principal ones being that it is not in any manner up to date, that the towing is still being done on it largely by horses and mules, and that the business has never been organized and conducted on modern lines. It has been seriously handicapped by the fact that improvements have been undertaken and discussed which would render the old type and size of boats obsolete; rendering it inadvisable as a business proposition for people to build new boats for canal business or to replace those outworn, with the possibility before them of a larger canal in the near future.

That the traffic on the Erie Canal has declined, it is true, but it would immediately spring up and grow to enormous dimensions if a proper barge canal were built in its place, if legislative restrictions on the capital of operating transportation companies were removed, and if the business were organized in a thoroughly up-to-date manner. It must not be forgotten that if the Erie Canal has stood still, or worse than still, for the last thirty years, the competing railroads have improved their transportation facilities enormously in ways which it is unnecessary to recount here.

But the most palpable error in this fourth conclusion of Mr. Wisner is his acceptance and statement as to the "failure of the 14-ft. Canadian canals to divert commerce from the lake and railroad lines." As a matter of fact, the Canadian 14-ft. canal system has not yet been fully completed, and it has not yet been used by any boats drawing 14 ft., and probably will not be for some time. Considerable work remains to be done in the canals and the St. Lawrence River before this transportation scheme is fully completed. In addition to this, the Canadian Government and private parties have only just begun work at Port Colborne and Montreal to prepare for the traffic which they expect to go through this commercial highway formed by the Welland Canal, Lake Ontario, and the St. Lawrence River and Canals. According to the papers, quite a number of boats are being projected and a number are being built to run on this route as soon as it is com-

plete, and Mr. Wisner has certainly jumped at a conclusion which is in no manner justified by the facts and present data. The 14-ft. Canadian canals may be determined hereafter to be failures, but it certainly has not been proven yet, in advance of their completion. Mr. Symons.

His premises being entirely in error, it follows that his conclusion "that a waterway of less depth than required for the passage of the best type of lake freighters cannot materially modify the transportation rates over existing routes" is unfounded and unjustifiable. In fact, even granting the premises, the conclusion is by no means justifiable. The barge canal proposed for the Erie Canal route has a capacity for boats four times the size of those now in use. To say that they cannot materially modify transportation rates is just as absurd as it would be to say that 8 000-ton steamers on the Lakes cannot materially modify rates suitable to 2 000-ton steamers.

To aid him in his contentions, Mr. Wisner is willing, apparently, to stand sponsor for the statement that in the case of wooden barges and steel barges of the same size and model, the power required to tow the wooden barges is about twice that required for towing steel barges, and that "the cost for towing per ton-mile for the wooden barge was about double that for the steel." This, he states, is based upon some experiments in towing by Captain C. V. Suppan, Chief of the Steam Navigation Service on the Danube. This alleged fact in regard to the difference in the cost of towing steel and wooden barges is so contrary to common sense and experience that it is difficult to understand how an engineer of standing would be willing to use it in an argument in favor of anything. The only difference there could possibly be would be in the skin friction on the outside of the boat. Assuming that the steel boat and the wooden boat were in equally good condition, the difference in the amounts of this skin friction would necessarily be very slight. This is one of the reasons why Mr. Wisner, in his comparative tables of cost of transportation, insists upon the transportation through the barge canal being done in expensive steel vessels, instead of cheap wooden ones. As a matter of fact, one of the strongest arguments in favor of the barge canal, following the general route of the Erie Canal, is that business upon it can be done in cheap light wooden boats, as these boats would not, at any part of the route, be subjected to the storms which prevail at times on the Great Lakes.

Mr. Wisner gives $4\frac{1}{2}\%$ as the rate of insurance on a fleet of barges operating on the canal. As a matter of fact, the prevailing rate is 2% for steamers and 1% for ordinary boats, making the average insurance rate on a fleet of one steamer and three plain barges less than $1\frac{1}{2}\%$, or less than one-third of the amount stated by Mr. Wisner. He has also increased the cargo insurance in some unexplained manner.

By swelling the cost of the necessary boats for operating on the

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canal in an entirely unnecessary manner, which largely increases the charge for insurance, interest, and deterioration, Mr. Wisner makes his showing favorable to the ship canal.

The steel boats estimated on by Mr. Wisner would be able to navigate the open Lakes, as the Cleveland steel boat fleets are doing today, and could run between the Lakes and the sea in competition with the large steamers on the proposed ship canal, and, because of their much lower cost per ton of carrying capacity (about one-third), and lower operating expenses, could furnish transportation cheaper than could the large steamers.

Mr. Wisner also predicates his findings on the lake ship going to New York and getting as quick dispatch, or nearly as quick, as it gets at the Lake ports. Now, this cannot be admitted as a reasonable probability. The only way in which it could get a quick dispatch would be to go to an elevator and discharge its cargo and return with little or no cargo. This would mean another handling of the cargo in New York and an added expense of about as much as the total cost of transportation on a barge canal. The conditions under which business is done in New York are such as to preclude the reasonable probability of a lake ship delivering its cargo into a foreign-bound ship directly, except occasionally. Nearly all the foreign-bound commerce of New York leaves the port as berth cargoes in the large ocean liners. These ships do not leave their docks, freight has to be brought to them, and there is not room at the dock for the ocean ship and the lake ship, while there is room for the canal's boats and the necessary means of transfer, such as floating elevators, etc. To get anything like the dispatch, at the Port of New York, on which Mr. Wisner figures, would require a very complete upheaval and reversal of the methods of doing business in this great port.

There would certainly be serious delays in the ordinary transaction of business, in getting rid of the cargo of a great ship, which delays could only be obviated by going to large expense in extra handling of the cargo.

Even if the port delays to the barges of a barge canal were as great in New York as the delays to the ship, these delays would not be so serious, as the cost per ton capacity for the barges is very much less than the cost per ton capacity of a great ship, and the operating expenses of the barges are very much less than the operating expenses of a ship, either moving or in port.

There are decided reasons for believing that it would be more convenient, and better for commerce, to have nearly all the western products arrive in New York in lots of about 1 000 tons, in place of having them arrive in lots of 6 000 to 10 000 tons. Nearly all our exports are shipped as berth cargoes in vessels carrying diversified loads, not more than 10 to 15% being shipped in full cargo lots. A cargo of

8 000 tons arriving in eight different loads would go to eight different ships and be transferred, as is the custom now, directly into the ship without its leaving its own berth. The advantages of this in economy and time saving are obviously very great. That it is sometimes more advantageous to divide a large amount of freight into several lots than to carry it all in one, is exemplified in the transportation of coal by water along the Atlantic seaboard. The enormous business of transporting some 30 000 000 tons per year is practically all done in barges of 1 000 to 2 000 tons, three or four of them being towed by one tug. The business of transporting this coal was formerly done in single steamers and sailing vessels, but the tow barge system has supplanted this method almost entirely, and the writer cannot but regard it as a lesson fraught with very great value to any student of the problem of connecting the Great Lakes with the ocean by a water route. Mr. Symons.

The data furnished by Mr. Wisner are not at all sufficient to prove that the Great Lake freighters could with safety make a speed of 8 miles per hour in the canal proposed by the Board of Engineers on Deep Waterways. There is much to be said on the other side. The fact that boats habitually pass through the short straight St. Clair Flats Canal at a speed of 7 to 11 miles per hour is not conclusive that it would be safe to maintain this speed with full-sized ships in a comparatively long canal, with more or less curvature, and rocky bottom and sides. If the ship canal has a commerce upon it in large ships sufficient to justify the enormous expense to be incurred in building and maintaining it, it must necessarily be fairly well crowded with boats at all times, day and night, in windy and stormy weather as well as quiet and pleasant weather, and under all circumstances. The writer cannot conceive of these ships being driven at a speed of 8 miles per hour and meeting and passing other ships without picturing to himself very great danger of accidents.

Experience demonstrates that accidents are bound to occur to ships navigating such a narrow channel, and that it will be necessary for them to move slowly and with the utmost caution. Any accident which leads to the sinking of a ship in such a narrow canal might, and probably would, in many cases completely block the canal until the ship could be raised and gotten out of the way. During the season of 1899 there were three incidents in the history of transportation on the Lakes which illustrate this danger and the serious consequences which are likely to be incurred through an accident. In the early part of September, 1899, one of the Great Lake boats, the *Douglas Houghten*, laden with ore, broke her steering gear, and went aground in the channel of the St. Marys River. In sinking she swung around across the channel and completely blocked it. It took five days of great effort to get this vessel afloat and out of the channel, and in the meantime 332

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vessels were blocked and unable to get by. This caused a great loss to the Lake carrying interests, probably over $500 000.

In the latter part of November another blockade of the St. Marys River Channel occurred, due to a collision in which three vessels, two steamers and a tow barge, were mixed up and stranded, and this caused a delay of nearly four days to some 167 vessels, and involved a very great loss.

In the early part of December a tow barge went aground in the channel leading to the St. Clair Flats Canal, blocking the canal for nearly two days and delaying 35 vessels.

Besides these greater accidents, delaying many ships, there are constantly being reported other accidents of a less serious character in these inter-lake channels, such as the sinking of individual vessels, collisions and damage, the stranding of vessels, etc., due to breaking of steering gear, mistaken signals, or boats taking a sheer. Besides, there is the likelihood of accidents to vessels at the locks themselves, causing detentions and blockades.

There is no getting over the fact that the home and place for large ships is in the wide free waters, and that when they enter the narrow waters they are subject to grave dangers, and must move with extreme caution. So great are these dangers on the narrow channels of 300 to 400 ft. width connecting Lakes Erie, St. Clair, Huron and Superior that the shipping interests of the Great Lakes are making strenuous efforts to get the Government either to widen them to 600 or 800 ft., or to build duplicate channels, one to be used by up-bound and one by down-bound vessels.

It does not do to shut our eyes to the perils of great ships in narrow channels. In spite of all precautions, such accidents are likely to happen in narrow channels traversed by ships of 7 000 to 10 000 tons capacity. The longer the channel, the greater is the likelihood of accident, and it is easy to imagine that in a ship canal, from Lake Erie to Lake Ontario, and from Lake Ontario or the St. Lawrence River to New York, such accidents, blockades and detentions would be of frequent occurrence, if used by many vessels. These would all tend to reduce greatly the average speed attainable in the canal. Of course, accidents and detentions are likely to occur on a small canal also, but, owing to the greater ease with which the smaller locks and boats can be managed, the dangers here are not so marked; besides, the results of accidents on a small canal are not so likely to be disastrous as in the case of a greater canal and larger boats. It is a much easier and quicker matter to lighter a small vessel carrying a few hundred tons than it is to do so with a great freighter carrying several thousand tons.

There is another point of view from which this problem must be looked at, and which should receive very serious consideration. The canal, if built, will be built by the United States at a cost of about

$200 000 000. If built by the United States the benefits should all accrue to the United States, but would they? It is the writer's very decided opinion that they would not. If a ship canal be built from Lake Erie to New York by the Ontario-St. Lawrence-Champlain route it would be more apt to redound to the disadvantage of American commerce than to its advantage. Such a ship-canal route would follow down the St. Lawrence until within about 50 miles of the seaport of Montreal. It would then branch off to New York, which would be reached only after traversing some 350 miles of canal, lake and river, and when at New York, commodities destined for most foreign markets would be further away from these markets than they were when they left the St. Lawrence. Such a canal would be of some benefit to our local and strictly domestic business, but it would just as certainly be a detriment to our inbound and outbound foreign commerce, tending strongly to take it away from New York and our other North Atlantic cities and build up the commerce of Montreal. Of course, to reach Montreal, Canada would have to add a short section to our ship canal, but this she would certainly do, and then it would be inconceivable that grain, lumber, iron ore, manufactured steel or other articles destined for foreign markets, reaching within 50 miles of Montreal, would retrace their steps through 350 miles of contracted waterway back to the Port of New York. Mr. Symons.

The same is true, though to a somewhat less extent, in regard to the ship canal projected by the Oswego-Ontario-Oneida-Mohawk route. If the Great Lake freighters, carrying from 7 000 to 10 000 tons of produce, should go into Lake Ontario, they could continue on down the splendid waterway of Lake Ontario and the St. Lawrence River as far as Prescott and Ogdensburg, only about 120 miles from Montreal, and then transfer into 2 000 or 3 000-ton barges to be taken through the Canadian canals to Montreal. All foreign-bound commerce would undoubtedly take this course rather than the route from Oswego to New York through 320 miles of contracted and dangerous waterway with its 590 ft. of lockage. It is altogether certain, too, that in this event Canada would soon enlarge her St. Lawrence canals so as to permit the Great Lake vessels to run directly to Montreal, and the resultant benefits, in that event, would be far greater to Canada than to the United States.

Whatever canal is built should be so located that its benefits would only accrue to the United States, and there is only one canal route between Lake Erie and the ocean of which this is true, and that is along the line of the present Erie Canal. This route is not available for a ship canal, but is available and well suited for a barge canal, and is the only route which should ever be considered by the people of the United States.

The point made by Mr. Wisner against the barge canal, that it

Mr. Symons. could only be fully and properly utilized by the organization of large transportation companies to operate boats on the Lakes and canal with elevators at Buffalo, and that these transportation companies and lake and rail lines would probably combine to maintain rates and thereby destroy the benefits from such a canal, is not, in the writer's opinion, well taken. Such a canal would be free to any number of transportation companies, just as free as the Lakes themselves, and while such a combination might be made, it is also equally probable that in that event other companies would be organized and do business at the lowest profitable rates. The charge of a possible combination to maintain rates would lie almost as well against the ship canal advocated by Mr. Wisner as against the barge canal. In fact, in some respects it would lie more strongly, for it would take less capital to break into a barge canal combination than into a ship canal combination.

Mr. Wisner says:

"Since 1880, when the traffic on the Erie Canal reached a maximum, the rate per ton-mile on the railroads from the Lakes to the seaboard has been nearly double that on the Erie Canal, yet during that time the business of the canal has diminished one-half, while that on the railroads has nearly trebled," etc.

While it may be true that railroad freight rates are double those on the canal if there be included all kinds of freight carried, and all the year round, it is not true if there be included only the heavy coarse freight ordinarily carried on the canal, and during the period of canal navigation. For many years the canal rates and railroad rates on grain, etc., have very closely approximated to each other during the period of canal navigation, the railroad rates going up at the close of this period. As an illustration it is to be noted that the prevailing rate of 3 cents per bushel, which the railroads have been charging all summer, has just been lifted by the railroad combination to 4 cents, an arbitrary increase of 33⅓%, to take effect November 1st, about the close of the season of canal navigation.

The writer is glad that he can so completely agree with Mr. Wisner in one respect, and that is in his belief that a canal for deep sea ships of 30-ft. draft is not advisable or justifiable. The writer investigated this matter and reported to this effect to the General Government in 1897. He has not yet seen reason to doubt the correctness of the conclusions reached in that report—that there is one type of vessel best suited for use on the ocean, another on the Lakes, and another on narrow canals and waterways; that economy of transportation demands that the vessel be suited to the waters which it traverses, and that no single type of vessel has been, or probably will be, devised, which is suitable to all three or any two of the waters mentioned. He also cordially agrees with Mr. Wisner that the depth

to be aimed at for the inter-lake channels and Lake harbors should be limited to that suitable for vessels of 20-ft. draft. Mr. Symons.

Mr. Wisner and others who advocate a ship canal, lay great stress on its influence in expanding the ship-building industries of the country and "restoring the Merchant Marine of the United States in foreign trade." The writer is unable to see much in this argument. Ships are going to be built on the seashore and on the Lakes just as fast as they are needed, and ships of the same character will cost nearly the same in one place as another. As an instance of this it may be mentioned that a ship of Canadian canal size has just been launched in Buffalo, destined for ocean trade, while at the same time the City of Buffalo is having a large steel fire tug built on the seacoast, the contract for the latter having been awarded after full competition. The mere transference of an industry from one section of the country to another is not in itself a benefit for which the whole country should be called upon to pay a large sum of money.

The foregoing is intended as an answer to a good deal that appears in Mr. Mayer's interesting, but rather transcendental, paper. Some of his theoretical deductions are based on entirely erroneous data. For instance, he bases some of his theories on an amount of tonnage tributary to a ship canal that is far beyond any reasonable probability at any time in the near future. If he were more familiar with the business of transportation on the Lakes he would know that the total tonnage passing through the Detroit River and the Sault Ste. Marie has little relation to the amount of tonnage that would pass through a ship canal from Lake Erie to the sea. The Detroit River and Sault Ste. Marie tonnage is made up principally of coal, ore, lumber and grain. Practically none of the coal would be apt to pass through the ship canal, but little of the ore, while possibly half of the lumber and two-thirds of the grain might be conceived as using the canal. Mr. Mayer's estimate of 36 000 000 tons as a reasonable amount of tonnage on which to base his estimate is far beyond reason. Even Mr. Wisner, strong advocate of the ship canal as he is, only uses 15 000 000 tons in his estimates. It is nearer the mark, for some years to come, to figure on 10 000 000 tons, with a possible increase to 15 000 000 or 20 000 000 tons in the not distant future. With an annual cost of about $9 000 000 and a tonnage of 36 000 000, Mr. Mayer computes an interest and maintenance charge of 25 cents per ton. With the tonnage reasonably to be expected, this would be increased to 90 cents, gradually diminishing to perhaps 50 or 60 cents. And it must not be overlooked that if the tonnage approaches anywhere near Mr. Mayer's 36 000 000, the alternative suggested by him of additional locks and facilities must be met, which will largely increase the interest and maintenance charges. At the Sault Ste. Marie there are now three locks: The American Weitzel lock, 60 x 515 ft.; the American Poe lock, 100 x 800

Mr. Symons. ft., and the Canadian lock, 60 x 900 ft. The tonnage passing through them all is something like 25 000 000 tons per annum. The American locks are now at times taxed to their full capacity to take care of the tonnage demanding passage, and it is one of the strong demands of the Lake-carrying interests that a new lock, larger even than the Poe lock, be built to accommodate the traffic. It is understood that the Board of Engineers on Deep Waterways proposes a single lock on the line of its ship canal about 60 x 600 ft., about half the size of the Poe lock at the Sault Ste. Marie, and only large enough for the passage of one large steamer at a time.

Experience at The Sault would indicate that as the Lake carrying business is distributed throughout the year, such a lock cannot be expected to handle much over 10 000 000 to 15 000 000 tons annually.

In regard to the number of trips on which the estimated cost of transportation is based, the writer has now only this to say:

In the transaction of a transportation business by great vessels on such a ship canal as advocated by Mr. Mayer and Mr. Wisner, there is a vast difference between a reasonable probability and a theoretical possibility. The writer conceives that his estimate of 10 trips per year between Buffalo and New York is the first, and the estimate of 16 trips between Chicago or Duluth and New York is the second.

Mr. Randolph. ISHAM RANDOLPH, Esq.* (by letter).—The writer lacks the data upon which to base a discussion sustaining his preconceived ideas in favor of a channel deeper than 21 ft. This question passes beyond the problem of construction and cost into the realm of political economy, and statesmen must decide how much the Nation should expend upon a channel designed to connect the mid-continent with the World's ocean highways and give the producers and consumers of the Middle West and Northwest access to the World's markets upon terms nearly equal with those of the Atlantic States. Of one thing, however, the writer feels sure, that any plan for connecting the Great Lakes with the Atlantic Coast should be executed in such a manner as to admit of progressive development to meet the maximum needs of a deep waterway. Locks and all permanent structures should be constructed for maximum depths even though the intervening channels be excavated at the outset for the 21-ft. depth advocated by Mr. Wisner. That is a concession to the greater project which seems to be justified by American faith in America's future.

Mr. Schenck. ARCHIBALD A. SCHENCK, M. Am. Soc. C. E. (by letter).—These valuable papers open up two important inquiries:

(1) Are Lake vessels for commerce on rivers and canals more profitable ultimately than small barges and canal boats?

(2) Should our "seaports" be located at the sea or in the interior?

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There is no doubt that the free ocean freights can be handled for less than ½ mill per ton-mile for long voyages. On the "half-way free" Great Lakes, freight can be handled for less than 1 mill per ton-mile, where the voyage is the longest possible—Chicago or Duluth to Buffalo. This voyage may include travel through short stretches of canal connecting large open lakes. Owing to the lack of intermediate large basins (such as are the Lakes), in the proposed long canal and canalized river through New York State, no freight rate can be positively given. No actual test has been made for such long distances of narrow canal crowded with deep-draft vessels so thickly, without relieving basins. A comparison by highest speeds is hardly a safe financial operation. A railway train on one road can make 10 miles per hour on long stretches of track—on another road it will make 40 miles. Therefore, does the latter road carry freight for one-fourth the rate of the other? The consumption of time and money on most railways is not in transit, but while waiting to get into transit. On the canal, crowded with numerous vessels, the passing of opposing and overtaken vessels will reduce the speed to one-half, often to one-fourth, occasionally to one-tenth of the maximum speed. The vessel must run "on caution card" most of the time, even when having the right of canal; all this, apart from the mechanical difficulties in a cramped waterway, and with poor steering power, which are well-known causes of retarding. The premise of Mr. Mayer—tested speed over measured lengths—leaves out of sight all the difficulties of transit over which the railway man grows sad, even on a double-track railway, and which will exist largely on a canal. Such difficulties and delays on a long and narrow canal would lessen his 8-mile speed to a small fraction of it as average speed; will multiply by several times his 0.6 mill per ton-mile, and will cut into several small pieces his $1.50 per ton saving.

With these allowances, he is then in competition on river and canalized river with the immense tows of small boats, and on the ocean with the immense ocean carriers. His boat has neither great divisibility nor great mass.

The cheapness of these great tows of shallow boats is seldom noted by those who urge deep-water canals. On the Mississippi about 30 000 000 tons have been carried annually at a rate of 0.5 mill to 2.0 mills per ton-mile, with trifling investment in vessels. The tonnage reaching Hamburg by the Elbe is on water from 2 to 6 ft. in depth. On the Rhine, the Elbe and the Oder, the "strings," or tows, reach 10 000 tons each. On the Hudson they run from 10 000 to 15 000 tons, with draft of 6 ft. The towage rate is about $\frac{1}{10}$ cent per ton-mile. This low rate is not the only, or, perhaps, greatest, advantage of these tows. Their divisibility enables them to secure return cargoes, or cargoes of various sorts for many uses and many ports. Their light

Mr. Schenck. draft enables them to enter a vastly greater number of ports, ports for which the expense of construction and maintenance is trifling compared with deep-vessel ports; to secure an immensely greater variety and number of customers and shippers; to gather their freight nearer the producing point and deliver it nearer the consuming point, with little intermediate tribute paid to middlemen. These tows more nearly resemble the railway trains, in their divisibility and power of reaching close to consumer and producer, than any other form of water transportation that exists or can exist. It is doubtful whether the cheapening on canals and rivers in freight of moderately deep-draft Lake vessels would equal in cash value the gain those light-draft vessels have. At the ocean shipping port they can gather about and get closely "in touch" with large or small vessels, in deep or shallow docks, as no deep-draft Lake vessel can. They are the convenient, adjustable unit, perhaps never to be supplanted in inland narrow navigation for freights.

Again, the Lake vessel is also at a loss in competing against ocean carriers. It is dwarfed, stunted by its inland channel and ports and its effort, so to speak, to run on both sea and land. The tendency of ocean carriers to greater tonnage and draft can readily be noted by examining a few well-known trans-atlantic steamers.

TABLE No. 5.

Steamer.	Length, feet.	Beam, feet.	Draft, loaded, feet.	Tons.
Umbria	502	57	28	8 128 Gross.
Teutonic	582	57	29	9 685 "
Majestic	582	57	29	9 861 "
City of Paris	580	63	27	10 500 "
City of New York	580	63	27	10 500 "
Kaiser Wilhelm	648	.....	.....	.....
Oceanic	704	68	.....	17 040 Gross.
New Liner, *Harland-Wolff*	750	.....	.....	12 000 Net.

The function of each class of vessel is essentially different. The proper style of inland vessel, small, penetrating everywhere; the ocean carrier, as large as the greatest ports will permit. The 24-ft. seaport entrance of former days, the 30-ft. entrance depth of to-day, are already outgrown; a 40-ft. entrance is now demanded. The increased tonnage is mostly clear profit, and the Lake vessel can never get that profit. It must go down before such ocean competition. It is neither one thing nor the other, neither truly inland nor truly oceanic. Our inland lakes, too large and dangerous for river vessels, too small and with ports too shallow for ocean vessels, are an inconvenient intermediate. A canal to connect two bodies of water having similar ves-

sels is reasonable. A canal to connect two bodies of water much different, not adapted to the same class of vessel, is not desirable, or likely to be profitable. It is partially like trying to connect a narrow-gauge road and a broad-gauge road for running through trains. Lake vessels will not fit an ocean—ocean vessels proper cannot get upon the Lakes or use Lake ports. The effort to extend these Lakes seaward, as if they were deep-draft ocean waters seeking similar waters, is likely to be costly and unprofitable. Hence, "let the Government attempt it, it can afford to lose." Mr. Schenck.

The pressure for this waterway appears to come from four directions:

(1) The great steel-producing plants, the Carnegies, Rockefellers, etc.: They can exterminate the middlemen, be producers and reach to the foreign consumer. Their gain comes, not so much in decreased transportation cost, as in annihilated middlemen. Only immensely wealthy concerns can thus act as producer, carrier and foreign merchant. The usual blocks of distance, into which commerce divides itself, must be made in all but such cases, and take place where bulk can most advantageously be broken—at the coast.

(2) From small shippers, to reach inland consumers: For these, the majority of the boats on canal and river should be small, receiving from the Lake boats as now, and delivering to them. The remedy of present cost lies in lessening transfer costs rather than in deepening waterways.

(3) The great mid-continental railways that reach from Pacific tide water to the Lakes: These are anxious to make seaports of their Lake terminals, and be independent of railways further east. Each wishes to unite Europe and Asia by a single line—its own.

(4) The numerous Lake cities, each eager to become a Greater New York:

All these efforts to transfer seaports to the heart of the continent are unnatural. Millions and hundreds of millions of dollars have been wasted, in recent years, in attempts to draw ocean commerce far inland. A few more hundreds of millions are now to be added, perhaps. The civil engineer, manager of transportation and capitalist, can find no larger or more important problem. It is worth the most painstaking study, with millions in it, or to be lost by it. It cannot be taken up as light reading or for temporary amusement. A correct, generally accepted decision as to whether our ocean ports should be far inland or far oceanward, would tend to save and make more millions than any other question the civil engineer encounters. This canal project is only one more struggle in the expensive contest of ports.

One of the causes of this contest has been that mere shipping ports and great marts of trade have been supposed to be one and the same thing. All that each town has aimed for has been to be a shipping

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port, a mere transfer table (with very little profit dropped in the transfer, it is found). All that railways have sought to reach has been a shipping point at which to dump their freight as near at hand and with as short a road as possible. The effort to ascertain the natural mart of trade and interchange, and to reach it has seldom been made.

The two alternates of location have been at the "head of navigation" and at the coast. Navigation is generally hydra-headed, and "the" head of navigation varies and dwindles in size and importance with draft of vessel until it becomes microscopic and unascertainable. An "immutable law" is claimed to put the great shipping port and mart of trade at this "head of navigation." The real test of commercial supremacy, such as the Lake ports are seeking by this canal, lies at the foot of inland navigation, always a distinct thing. This is the outermost point where inland vessels and great tows can safely go and transfer into the great ocean carriers. It is where the two can unite without sacrifice to either in respect to deep draft for ocean or light draft for small waterways.

At such a point the ocean vessel, the river vessel, the railway, can all get together. It is the only real radial point on the earth's surface. Land, ocean, coast, all productive areas, are naturally tributary and accessible to it. If the ocean carrier comes hundreds of miles inland, it passes rich areas, full of business. If it brings freight for this coast area, that freight must have a double needless journey after delivery inland. The coasting vessels must come far inland to exchange freights with the ocean carrier. The railways must carry back nearer to the coast what has already passed the coast inbound.

In support of the seaport far inland, and expensive projects for bringing vessels to it, existing ports are quoted. They are the main apparent argument. It is said that vessels must penetrate to the consumer, and the mart of trade be there. The consumers passed and ignored on the inland journey are not counted as of importance. A few figures in Table No. 6 will indicate what rich productive areas would be run through if a vessel could and did come far inland past the territory of each road named.

TABLE No. 6.

Road.	Through tonnage.	Local tonnage.
New York Central	2 023 133	14 598 064
Pennsylvania	2 189 804	35 809 588
Southern Pacific, Pacific System	738 914	4 949 142

Such are some of the rich tonnage-producing territories which the new Lake vessels would ignore and run past, in order to reach the

inland port and get "nearer the producer and consumer." The vastly greater number of buyers, greater number of profitable whole-cargo lots, greater radial possibilities of distribution to all the country, are ignored by the vessel whose only aim is to go burrowing far into the land, in place of sending its load, promptly on reaching land, to every possible direction. Mr. Schenck.

The actual ports cited as favoring the vessel's search inland, are numerous. None of them is really far inland, many wish they were less so. Some of the "inland ports," as contrasted with the ocean or coast ports, are the following:

"Inland ports"—Hamburg, Bremen, London, Glasgow, Gloucester, Montreal, Philadelphia, Baltimore and New Orleans.

Some of the coast ports are Liverpool, Southampton, Boston, New York and San Francisco.

These inland ports were located before railways reached readily to the coast. They attained importance when slow water transportation was the only form of transportation. They were in areas which had developed close to the rivers (then the only transportation routes) as towns now spring up along railways. The draft of vessels was small. Time was not an object in travel, in making sales, in turning over capital. In the present days time governs in all these, as essential; speed in transactions multiplies capital. Quick fluctuations compel quick deliveries by ocean carriers. Protection is afforded to commercial cities at the coast. Fresh water does not have to be sought far inland.

Hamburg was founded in 808 A. D., became a free city, and secured valuable commercial privileges which more than compensated vessels for going a short distance inland. It is in a fine radial location of water transportation, having tributary to it 2 000 km. of waterways. It has expended immense sums for facilities, having 300 acres of basins, many miles of wharves, 30 000 sq. ft. of storage. Its facilities are worth $50 000 000 per annum to commerce. Railway transportation came too late to change its location.

Bremen is not a port, having only 8 ft. of water.

London was located under early conditions. Although it often in early days congratulated itself on being inland a short distance, because of protection from hostile fleets, it has regretted it for commercial reasons, and made every effort to overcome its disadvantages. Since the increase of railway facilities, its annual tonnage has become about 17 000 000, against 20 000 000 for Liverpool and much for Southampton.

Glasgow is in a great coal and iron producing country. It is not a commercial but a manufacturing city, and attained a population of 300 000 before railways came.

The American ports named as inland were also located and grew to

Mr. Schenck. large size, as a result of water facilities, before railways came. New York, a coast port, once much smaller than Philadelphia, is now many times larger. Boston's foreign commerce exceeds Philadelphia's many times. The inland port of Albany and the inland ocean waterway, the Hudson River, were deserted by ocean vessels through railway competition which placed the freight down at the ocean for the ocean carriers, and through competition of the great tows on the Hudson. No better practical illustration of how needless is an inland waterway for ocean vessels can be found than this same Hudson River, on which this inland attempt is desired to be renewed.

Philadelphia made every possible effort to draw ocean vessels generally to her wharves. The immense capital and tonnage of the Pennsylvania Railroad were backing the attempt. Great elevators were erected. The river was deepened and range-lighted by Government. The ocean business failed to come, except in years when coast ports and steamers of all drafts were overtaxed. Much of the elevator machinery went to the junk shop. President Roberts read the burial service as follows before the directors:

"Some years ago you established a steamship company, the American Steamship Company, fostered by your corporation, in which you took four-sevenths of the original stock, afterward increasing that from time to time until you had nearly $1 200 000 invested in the capital stock of that steamship company.

"That $1 200 000 has been totally sunk. In addition to that, this company has faithfully paid the obligations, all these years, at the date of their maturity, so that they have paid in the neighborhood of $2 500 000, more as a contribution on the part of your corporation to endeavor to build up the commerce of this port; not an illiberal contribution, and one which has given the managers of your corporation some anxiety as to whether it was right or proper; but right or not, it is all gone."

Similar bad results are becoming observable at Montreal, New Orleans and Portland, Ore., while Boston, New York and San Francisco, well to seaward, are wearing no funeral colors, and plucky Galveston, seaward and even in the sea, is reviving, and shipping its greatest cargoes to-day. There may be another Philadelphia experience on a scale of hundreds of millions instead of millions. This time a rich nation, instead of a rich corporation, will be asked to take the risk and bear the loss.

Mr. Clarke. THOMAS CURTIS CLARKE, Past-President, Am. Soc. C. E.—All are agreed upon the necessity of some water communication, between Lake Erie and New York, better than that which now exists, as it has shown its incapacity.

Some advocate a 12-ft. canal to pass barges which they hope could navigate the Lakes and avoid transhipment. The speaker formerly favored this plan, as he then believed that the cost of a deeper canal would be prohibitory.

Mr. Clarke.

Mr. Wisner has shown that the cost of a canal 21 ft. deep, from Lake Erie to New York, through the Mohawk Valley, would be $200 000 000, and by way of the St. Lawrence and Lake Champlain $15 000 000 less.

He considers that if the canal were made deeper, the greater interest on its cost and its depreciation would exceed the saving in transportation.

He shows that a 21-ft. canal gives economy of transportation even after adding the charges for interest and depreciation. This is the first time that this statement has been positively made.

The writer agrees with Mr. Wisner in believing that the sum of $200 000 000 is not prohibitory—that a canal for the largest ocean vessels will never be made on account of its enormous cost—and that his figures of cost of transportation are substantially correct.

His reasons are briefly these: Experience has shown that a canal, requiring transhipment of freight at each end, cannot compete with all-rail, or rail and lake navigation.

A canal 12 ft. deep would probably pass tows of barges large enough to navigate the Lakes. It would, however, require transhipment at sea ports, and could not compete in economy with a canal large enough to pass Lake and ocean vessels, if the cost of such a canal did not stand in the way.

In the speaker's opinion, Mr. Wisner has proved that its cost would not be great enough to overbalance its economy of transportation, if made 21 ft. deep.

Can steamers, fit to navigate the Lakes and pass this canal, navigate the ocean economically ?

The answer is, that such vessels, or even smaller ones, have done so for many years. What is to prevent a tow of large schooners with five or six masts and having auxiliary power, from passing through such a canal?

It is perfectly true that larger vessels, such as those running between New York and European ports, would show greater economy on the ocean, but not in artificial waterways.

It is believed that the Champlain Route would be less opposed by vested interests than the Mohawk Route, as the destruction of property would be much less.

The estimates of damages are:

By Mohawk Route	$14 039 000
" Champlain Route.....	6 259 000

Private capital probably would not invest in either undertaking; nor would the State of New York do so without an entire change of its present policy, which seems unlikely.

The United States—the richest power in the world—can easily afford to construct this line of communication. It is necessary to first

Mr. Clarke. get a congressional majority in its favor. Some years ago that would have been impossible. Now, it seems to be possible.

The City of Chicago, after having expended $34 000 000 on her drainage canal, 24 ft. deep and large enough for Lake vessels, has offered it to the General Government on condition that the same scale of navigation shall be continued to the Mississippi River.

L. E. Cooley, M. Am. Soc. C. E., in a paper presented to The Western Society of Engineers, estimates the cost of a 20-ft. waterway from Chicago to St. Louis, 360 miles long, at not over $140 000 000.

The problem of extending the same depth from St. Louis to the mouth of the Mississippi, some 1 100 to 1 200 miles, is as yet unsolved.

There is much to be said in favor of the plan advanced by James A. Seddon, M. Am. Soc. C. E. (described in a paper presented to The Western Society of Engineers), for preventing floods and maintaining depth of water in the Lower Mississippi by the construction of a reservoir system formed in the bottom lands between the river and the bluffs. These reservoirs would retain flood waters, and let them out during seasons of low water.

Thorough surveys should be made by the United States Government to ascertain the facts. Mr. Seddon's estimate—$50 000 000—seems to be low.

The interesting fact is, that a union of interests between the western, southwestern and eastern States can now possibly be brought about to construct this great system of internal navigation from New York to Chicago and thence *via* New Orleans to the Gulf of Mexico.

The proposed Isthmian Canal is a vital part of this scheme. If that canal alone were built it would give only the Atlantic cities and New Orleans a short line to the Pacific, and the Pacific cities one to the Atlantic. If the entire scheme were carried out, it would take in the whole central part of the United States.

The total cost, including the Isthmian Canal, would probably not exceed $600 000 000. Some years ago that sum would have shocked careful financiers. But now that United States bonds can be placed bearing 2%, it means a yearly tax of $12 000 000, or about 16 cents per head of the population.

The United States has now become a World power, exporting its agricultural and manufactured products and coal, iron and copper to all countries. Its imports and exports have increased nearly 50% during the last six years, or from $1 710 000 000 to $2 427 000 000. The exports alone have risen from $921 000 000 to nearly $1 500 000 000. Such an increase has never before been seen in the history of the world.

If we wish to preserve this enormous trade, in the face of the sharper competition which must inevitably soon take place, we must give it the least expensive routes of transportation. The railways will take

care of it during the season of closed navigation; during the open months, such a scheme as has been outlined is necessary to enable all of our States to reach countries on both the Atlantic and Pacific Oceans by the shortest and least expensive routes. Mr. Clarke.

Nature has already done much to create this vast internal navigation, and we would be lacking in energy if we did not apply from our surplus revenues the sum necessary to complete what Nature has begun.

When this is done, the seat of the world's commercial empire will be transferred from Europe to that part of the United States where grain, coal, iron and copper lie side by side, controlled by the most energetic and inventive people that the world has ever seen.

EDWARD P. NORTH, M. Am. Soc. C. E.—It is a matter for congratulation that members of this Society turn from considering expert measurements of quantities to questions involving large additions to the service and convenience of mankind, and essay to direct those large sources of power in Nature—public opinion and the service of capital—to increasing the facilities for transportation and decreasing the cost of distribution over large areas of this country, as in the two admirable papers before us. Mr. North.

It is also pleasing to notice that both authors, though proceeding by different routes, reach substantially the same conclusions, viz., that with near-by railroad trains carrying 2 400 tons and a 14-ft. canal parallel to it, a 10-ft. canal may influence freight charges, but can neither control such charges, direct the course of commerce, nor prevent the present system of discriminating charges against production and consumption in this country generally and the commerce and industries of the City of New York in particular. And any money invested in procuring such inadequate transportation facilities must fail to return a normal reward.

In view, however, of the rapidly expanding trade of the Great Lakes, the determination to make their governing depth 24 ft. and the probability of a waterway of large capacity connecting the Lakes with the Gulf of Mexico, doubts may be felt as to the advisability of limiting to 21 ft. the depth of what should be one of the largest channels of distribution, or as to imposing tolls on a traffic which it is wished to develop. The toll proposed is not large, either absolutely or in relation to the probable value of the goods to be transported, 2 to 2½% on the value of the goods passing The Soo, and will not operate as does the yearly abstraction of $15 000 000 or $16 000 000 from the resources of those trading through the Suez Canal; a most onerous impost that must in part account for a tonnage of 8 000 000 or 9 000 000 sufficing for the wants, or capacity, of 1 100 000 000 people, while the 40 000 000 served by our lake carriers use 40 000 000 tons.

But to some extent any toll decreases traffic, principally by preventing or hindering the production and marketing of low-valued commodities, also by diverting travel or freights to other routes. The

Mr. North. marked differences in the development of freight and passenger traffics in this country on the one hand, and in European countries on the other, seem to show the effect of high and low charges on the volume of traffic. Poor's Manual gives very full statistics of the traffic on all our railroads, commencing with 1882. From these data Table No. 7 has been made, excepting in the columns as to population, which for 1899 has been taken as 75 500 000.

Here, the average passenger rate is persistently high; higher, it is thought, than in other countries. The freight rate, which in 1882 was lower than in any other country and about half the passenger-mile rate, is now, according to Mulhall, less than half the freight rates in any European country, and 36.3% of the passenger rate. As a consequence, the passenger mileage has increased 93.3%, while the ton mileage has increased 223.1 per cent. In European countries, on the other hand, there has been conservatism in the matter of freight rates; but, through zone tariffs, improvements in the comforts of third-class carriages, etc., average passenger rates have been materially reduced, and though there is no knowledge of such full statistics as those for American roads it is thought safe to say that the passenger traffic has had a growth approximating to that of American freights, while the freight traffic has developed on lines somewhat parallel with the development of passenger movement on American railroads.

TABLE No. 7.

Year.	Miles operated.	Rate per Mile, in Cents.		Miles transported. 1 = 1 000 000.		Gross Receipts. 1 = 1 000.		Transported per Mile Operated.		Transported per Inhabitant. Miles.	
		Passengers.	Freight.	Passengers.	Freight.	Passengers.	Freight.	Passengers.	Freight.	Passengers.	Freight.
1882....	95 725	2 447	1 236	7 688	39 302	188 137	485 778	80 313	410 572	146	748
1899....	186 280	2 002	0 726	14 860	126 992	397 560	922 436	79 770	681 725	197	1 682
Inc. or Dec..	+94.6	−18.2	−41.2	+93.3	+223.1	+101.7	+89.9	−0.007	+66.0	+34.9	+124.9

It may be claimed that the figures given in Table No. 7 do not fairly present the relations existing between our freight and passenger traffics, as no account is taken of the influence of electric railways paralleling our railroads, and the decrease in passenger traffic since 1894. But the effort of continued conservatism in upholding passenger rates, after a full recognition of the fact that a reduction would develop

such large accessions to the traffic as to require additional accommodations, is exactly the point for which attention is solicited. By this general conservatism, which is well typified by the story of the New England directorate which refused its commuters' request for an additional train with the assertion that in a short time they would crowd it as uncomfortably as the trains they then had, the railroads of this country possessing a right of way with much if not all of the necessary grading and track laying done, and its passenger department organized, have forced their patrons into the expense of new organizations, new rights of way, grading and track, and experiments with an undeveloped motive power, that the circulation of passengers on lines parallel to their tracks might not be unduly curtailed by high rates of passage. This does not, it is submitted, vitiate the deductions apparent from the table. Nor does the fact that the electric roads are likely to add materially to the convenience and wealth of the country throw doubt on the inference that if passenger fares had been reduced as freight rates have, the passenger mileage would have kept pace with the freight mileage. Mr. North.

The comprehensive and valuable system of statistics inaugurated at The Soo in 1887 and continued by the United States Engineers since then, statistics which have done so much to strip the value from those conservative predictions which vested interests will always call expert and authoritative, show that, for the five years ending with 1891, 37 352 066 tons of freight were carried for $45 913 715, or $1.23 per ton; and for the five years ending with 1899, 96 774 880 tons of freight were carried for $77 065 077, or $0.796 per ton. Here a fall of one-third, in the cost of transportation, was paralleled by an increase of nearly two and two-thirds times, in the freight transported. Or, to use another standard of measurement: During the first period mentioned, the freight charges on cargoes valued at $12.73 per ton were 9.66% of such values; and during the last on cargoes valued at $11.23 per ton, the freight charges were only 7.09 per cent. The average hauls were, for the first period 806 miles, and for the second 835 miles.

A case somewhat analogous to the foregoing was mentioned by Mr. Vreeland, President of the Metropolitan Surface Railway of New York City: On the Madison Avenue line the time of a trip with horses was about 1½ hours, and the road carried 17 000 000 passengers. On the introduction of electricity the time was shortened to about 1 hour and the road carried 50 000 000 passengers. In the first case a reduction of one-third in the cost of service was accompanied by an increase of freight carried by two and two-thirds times. In the other, a reduction of one-third in time without reduction in cost of passage was accompanied by an equal increase in the number of passengers carried.

Unless the above-quoted figures are inappropriate, they show that if we are to have the full encouragement to production and consump-

Mr. North. tion due to a waterway convenient for the exchanges between the 40 000 000 tons of traffic on the Great Lakes and the 79 000 000 of entrances and clearances at the Port of New York, as now estimated, the traffic should pass through ample channels unvexed by toll gates as well as transfer charges. But if the prospect of tolls is necessary to induce the construction of the canal, they should be imposed, as there would still be left a large margin of profit in comparison with present rates.

It may be well at this place to recapitulate the work done and the projects brought forward for cheapening transportation between the Great Lakes and the harbor of New York. Commenced in 1817 and completed in 1825, with a cross-section of 136 sq. ft., the Erie Canal added so much to the wealth of the State that it was determined in 1835 to enlarge its cross-section to 429 ft., an increase of 215 per cent. This enlargement was not legally completed until 1862, although the increased cross-section was available for traffic some years before that date. The law authorizing this enlargement prescribed a nearly rigorous adherence to the original location. In 1897, work was commenced on a further enlargement to 562 ft., an increase of 23 per cent. This was to be accomplished on the plan advised by Horatio Seymour, M. Am. Soc. C. E., then State Engineer, by deepening the prism from 7 to 9 ft. An appropriation of $9 000 000 was made for this purpose, no improvement on the original location being contemplated. In the summer of 1898, the appropriation being exhausted, work was suspended, the State Engineer estimating that it would cost $4 800 000 to finish the improvement of the Erie, Oswego and Champlain Canals. Work has not been resumed.

Tolls, which in their aggregate are greater than all the expenditures on the canals of the State up to the present time, excepting for interest, were collected on local and through freights until 1882.

In 1884, Elnathan Sweet, M. Am. Soc. C. E., State Engineer of New York, read a paper before this Society advocating the enlargement and relocation of the Erie Canal so that it should pass the largest lake vessels and be fed for its entire length from Lake Erie.

In conformity with a law of March 2d, 1895, a mixed commission, consisting of three citizens of the United States and three of Canada, reported in January, 1897, recommending, as was thought probable, surveys of two routes, both through Lake Ontario, one *via* the St. Lawrence and Lake Champlain, the other through Oneida Lake and the Mohawk Valley.

An appropriation bill of 1897 provided for the appointment of a board of three engineers known as the Board of Engineers on Deep Waterways, to make surveys, examinations and estimates for a deep waterway between the Great Lakes and the Atlantic tide-waters. This board was confined in its power to making surveys, etc., on the

routes recommended by the Deep Waterways Commission, which reported in January of that year. This report has not yet been given to the public, but some of its conclusions are given in the paper by Mr. Wisner, who was a member of this board. Mr. North.

In 1897, under requirement of the River and Harbor Act of 1896, directing the Secretary of War "to cause to be made accurate examinations and estimates of cost of construction of a ship canal by the most practicable route, wholly within the United States, from the Great Lakes to the navigable waters of the Hudson River, of sufficient capacity to transport the tonnage of the Lakes to the sea," Major Thomas W. Symons, M. Am. Soc. C. E., reported on what he calls "the broader view of the subject," recommending a ship canal through Lake Ontario, water which is owned in common by this country and Great Britain. That on completion of the Seymour plan, and the removal of restrictions as to capital of companies operating on the canal, the Erie Canal would "give commercial advantages practically equal to the commercial advantages which would be given by a ship canal." That a barge canal, with a cross-section of 1 208 sq. ft., "will enable freight to be transported between the East and West at a lower rate than could a ship canal (cross-section 4 176 ft.) navigated by large lake or ocean vessels."

Actuated, possibly, by the political uses made of the failure of a popular estimate of cost to complete the enlargement provided for in "the $9 000 000 act," the Governor of this State asked five eminent engineers and business men in connection with the State Engineer and State Superintendent of Public Works to form themselves into a "Committee on the Canals of New York State." This committee reported, in January, 1900: That the canals should not be abandoned:

"That the project of a ship canal to enable vessels to pass from the Upper Lakes to New York City (or beyond) without breaking bulk is a proper consideration for the Federal Government, but not by the State of New York."

They also recommended a modification of Major Symons' barge canal, cutting down the maximum size of the boat usable from 200 × 30 × 10 ft. to 150 × 25 × 10 ft., thus reducing the capacity from 1 500 to 1 000 tons. This, by some unexplained mistake, is characterized as enlarging the waterway of the State of New York to its "utmost limit."

In the spirit of this report, a law appropriating $200 000 for a survey for a canal of the recommended size was passed in the spring of 1900, limiting the survey to "the present route of said canal," excepting some minor changes between Buffalo and Syracuse. This estimate is expected in January, 1901.

Lastly, "The New York Commerce Commission," consisting of five eminent citizens, appointed in 1898, made a report in January, 1900, setting forth, among other conclusions:

Mr. North.

"The decline in New York's commerce has been steady and continuous for many years; it has been more pronounced during recent years, and has now reached serious proportions in actual loss of exports."

"The loss to New York is due in great measure to a discrimination against New York in railroad rates imposed by an agreement, known as the differential agreement, between the trunk-line railroads of the American Atlantic sea ports, including the New York railroads."

"The differential rate applies, not only on products destined for export, but also destined for local consumption by the people of New York City."

"The State has it within its power, through an adequate improvement of the Erie Canal, not only to apply the remedy that will secure it against further loss of its commerce, but will secure to it, as well, the restoration of that which has already been diverted."

The commission recommended the completion of the current enlargement, with a cross-section of 562 sq. ft., as adequate, acquiring additional terminal grounds and piers, and that certain laws be amended, particularly as to elevating grain.

This arrangement between the trunk lines reaching the Atlantic seaboard, giving differential rates on grain, both for domestic consumption and for export, is, in the aggregate, a serious injury to our farmers. The cheapest route for export grain *via* Atlantic ports is through New York, but, in favor of other roads and other cities, grain for New York has been for years penalized with a differential that amounted to 1.8 cents per bushel on wheat and 1.68 cents on corn; this has been lately reduced to 0.9 cent. During the five years ending with 1899, the average of the average rates charged on wheat, Chicago to Buffalo, as returned by the Merchants' Exchange of Buffalo, has been 1.82 cents.

Of course, it is perfectly competent for a committee of the New York Chamber of Commerce "to look with complacency, if not with actual pleasure" on the consequent diversion of grain exports to other ports. But is the man who grows the grain, which is burdened in any case with a relatively high cost of transportation, to look with any approximation to pleasure on a practice which puts an additional charge on his produce? As the committee says: "An adequate improvement of the Erie Canal," will apply the remedy. Their opinion, however, as to what is adequate, is even more restricted than that of the Committee on Canals of New York State.

It will be noticed that though sixteen sessions of the State Legislature have been held since Mr. Sweet read his able paper before this Society, advocating a radical enlargement of the Erie Canal, and two commissions have been appointed by as many presidents, some influence has seen to it that no survey has been made for a ship canal which would not be of greater use to Canada than to the United States. And it is possible to assert that a route through the richest and at one time the most prosperous section of this State "is not available for a

ship canal," although no one can show any reason that on a judicious location a canal of large cross-section should cost more per mile between Buffalo and Oneida Lake than between that lake and the Hudson River. Mr. North.

Agreeing fully with Mr. Wisner that: "The dimensions which should be given to a waterway between the Lakes and the Atlantic depends upon the economic depth which can be obtained and maintained in the water routes to be connected," and accepting his estimate that the interest and fixed charges for an increased depth in the Lakes from 21 to 30 ft. would amount to an annual charge of $2 205 000, or 5.51 cents per ton on the traffic now passing Detroit, but taking exception to his declaration: "The actual saving in the cost of transportation on the Lakes by using deeper draft vessels is only about one-half the above estimated fixed charges," and differing from the deduction, "the interest and maintenance account will exceed any expected returns from lower transportation rates;" reference is made to the previously mentioned valuable statistics of the traffic at The Soo.

Although, as set forth in the Report of the Committee on Canals of New York State, previously referred to, the railroads were able to partially starve the Lake marine when there was a depth of only 11½ ft. on the miter sills of the locks at The Soo; the traffic through that waterway since the opening of the Weitzel, or 16-ft., lock in 1881, has been phenomenal. Opened in 1855 to a traffic of 106 296 tons, its traffic for 1881 was only 2 092 757 tons, but in 1895, the year the Canadian, or 20-ft., lock was opened, it had increased to 16 806 781 tons. In 1899, 21 956 347 net registered tons of shipping passed through the locks at The Soo, carrying 25 255 816 net tons of freight valued at $281 364 750. This freight was carried an average distance of 827 miles for $21 959 707, or at the rate of 1.05 mills per ton-mile, which is about 13% higher than the average cost for the three preceding years.

During the thirteen years for which we have returns covering the tons and value of freight, the distance carried and the cost of carriage, as well as the registered tonnage, the cost per ton-mile has decreased from 2.30 mills in 1887, when 5 494 649 tons were carried, to 1.05 mills in 1899, when 25 255 810 tons were carried. This is a decrease concurrent with the deepening of the Lake channels, and largely dependent on such deepening, and justifies the prediction the president of the Great Northern Railroad made while discussing the project of General O. M. Poe, M. Am. Soc. C. E., for a 21-ft. channel: That it would cut the Lake freight rates in two.

Mr. Wisner estimates the annual charge to the 40 000 000 tons passing through the Detroit River, due to deepening the Lake channels and harbors to 30 ft. as 5.51 cents per ton. If the length of haul by Detroit is equal to that through The Soo, 827 miles, the cost of deepen-

Mr. North. ing the Lake channels and harbors will be 0.076 mill per ton-mile. This would set the cost of transportation back to about the average of 1892 and 1893, if there was neither reduction in freight charges due to the larger channels nor increased production of freight to be transported. Neither of these suppositions is possible. The increased charge of 5.51 cents per ton would be divided by 80 000 000 within a few years after the deepening was effected, and while the larger carriers might not again cut freight rates in two, they could be expected to cut off about one-third of the present rates, leaving an average freight rate of 0.6 mill per ton-mile. This does not seem an unprofitable rate, in view of the volume and steadiness of the traffic and the average sea rates.

The assumption, that the traffic passing Detroit soon after, if not with, the earliest possible completion of 30-ft. channels and harbors will be 80 000 000 tons, is not thought too large for realization, as the traffic for some time, as shown by Mr. Mayer, has been doubling every six years, and the Chief of Engineers is reporting to Congress that prompt action in doubling the capacity of the St. Clair Flats Canal is necessary and important to the safety and convenience of the vast commerce of the Great Lakes. And deepening the channel to 23 ft. has already been commenced in the St. Mary's River.

Proposals have been made that the Erie Canal should be given to some railroad as a right of way, and numerous other schemes have been proposed like "the $9 000 000 plan," to impose a general hardship to the financial advantage of a few transhippers at Buffalo and New York. And lastly, we have the project to be submitted to the next Legislature of New York State to abrogate the necessity of transhipment at Buffalo by imposing a high rate of freight on the Lakes. The possibility of this perspective, however, has doubt cast upon it by the vociferous demands of "the friends of the canal," that large expenditures shall be made at both the Lake and Atlantic termini, that freight may be transferred more conveniently. All of these plans oppose the interests of both producers and consumers.

It is to the advantage of the City of New York and the New Jersey cities on the bay that this improvement should be so ample and commodious that no better or cheaper route between the interior of the country and the seaboard can be reasonably expected.

It is to the advantage of the State of New York that the canal should pass through the State and should be so large that the factory sites along its banks may have all the facilities for manufacturing offered by low freight rates, without transhipment, that the cities on the Lake front now have.

It is to the advantage of those living in the country to the west of this canal that it should be so located as to build up centers of production and consumption as near to them as practicable, and that its

capacity for speedy and economic traffic should give the greatest possible encouragement to marketing those low-cost products which cannot stand railroad charges; as well as reducing the cost of all freight transportation, that the producer and consumer may have more to divide between them. Mr. North.

It is also to the advantage of the whole country that many waterways should be constructed or developed, that their control over railroad freight rates, as described twenty years ago by the late Albert Fink, Past-President of this Society, may be maintained and increased.

It is fortunate that the Hudson River carries a depth of 30 ft., excepting at a few unimportant points, nearly to Coxsackie.* This leaves only about 375 miles, out of approximately 1 500, to be improved. With an economic depth of 30 ft. obtained in the Great Lakes, there seems to be no doubt that the channels connecting their commerce with our cities on the Atlantic coast and with the water front of the whole world should have an equal depth.

As no survey has been made for a ship canal between Lockport and Syracuse, an approximate estimate of cost may be made by adding 50% to the estimate of the Board of Engineers on Deep Waterways for the low-level, Oswego-Mohawk 30-ft. plan from Duluth to New York, given in Table No. 2, viz., $317 284 348, as covering the increased cost of building the canal wholly within the United States, and a further addition of $36 000 000, the estimated cost of improving the Lake harbors. The aggregate, $512 000 000, at 3% interest, and 0.5% maintenance, would give an annual charge of $17 920 000. This sum would be directly repaid to the country by a saving of 0.27 mill per ton-mile on 80 000 000 tons carried an average distance of 827 miles.

The sum of 0.27 mill per ton-mile necessary to be saved on the estimated Lake traffic, when the channels from Duluth to New York are deepened to 30 ft., to directly recoup the country for the total expenditure would be reduced by the additional haul of 500 miles on all freight either destined to or originating in the Port of New York or beyond it. There would also be a further reduction due to eliminating the cost of transhipment at Buffalo, which Major Symons puts in his report as 27.1 cents per ton for package freight. These direct savings can be partly estimated, but the indirect saving due to the absence of delay and damage inseparable from transhipment cannot be computed with accuracy.

In estimating the amount of traffic attracted to a 30-ft. canal of sufficient cross-section, notice should be taken of the facts that there is no other people able to employ a ton-mileage equal to ours. The traffic passing Detroit is larger than any other water-borne traffic through one channel and is growing rapidly. The entrances and clearances at the Port of New York are more than twice those of any other seaboard port.

* From there to Troy the State and General Governments have increased the depth from 4 to nominally 12 ft.

Mr. North. The traffic of this port has for some time been estimated at 70 000 000 tons. E. L. Corthell, M. Am. Soc. C. E., after careful research, preparatory to presenting a paper, "The Harbors of the World," to the VIIIth Congress on Navigation, held at Paris in 1900, states that the total entrances and clearances at this port are 79 544 653 tons. This tonnage he divides as follows:

In the interior trade	25 093 000 tons.
" coastwise	39 250 000 "
" foreign*	15 201 653 "

As a matter of comparison, the entrances and clearances are:

For Liverpool	25 093 000 tons.
" London	30 215 000 "

It will be noticed that less than 20% of the tonnage of this port is engaged in foreign trade, and the aggregate tonnage of Liverpool and London, foreign and domestic, is 16% less than the domestic tonnage of this port.

Some nine years ago a board of engineer officers on the improvement of the Hudson River reported that the traffic of this stream was 18 500 000 tons, 3 500 000 of which were contributed by the State canals. Although it may seem incredible, it is a fact that many of the best thinkers to be found in the City of New York oppose materially increasing this contribution of the canals to the tonnage of their port, on the plea that the grain-handlers here and in Buffalo will be deprived of their opportunity to penalize production in the Northwest by exorbitant transfer charges on grain for export.

The population and wealth of the Port of New York is not dependent on its exports. Its unique natural position, making it the largest "port of call" in the world, is due to its having two large waterways back of it, viz., the Hudson and East Rivers. Adding to its natural advantages, the construction of the Erie Canal forced all railroad terminals to concentrate here, making its position the best in the world for manufacturing; for here raw products for manufacture can be assembled, and, the finished materials distributed to consumers at less cost than elsewhere, and, both in value of merchandise produced and in amount of wages paid, it is peerless. The present census will probably show that the wages paid in manufacturing industries in the cities and towns on the Bay of New York are nearly equal to the value of exports from the Port, and provision for traffic through the proposed canal that neglects the demand of New York and the cities ancillary to it on the Atlantic coast will fail in economic value, not only to the Atlantic front of our country, but to the interior.

No estimate of the freight entering and leaving the canal should

* A writer in the *Forum*, December, 1900, states that the total entrances and clearances at the ports of the United Kingdom for 1899 were 209 348 081 tons. Of this, 97 782 887 tons were entered and cleared in the foreign trade.

neglect the manufacturing potentialities presented by the banks of the proposed waterway, which for nearly its whole length would offer factory sites with water and rail communication. The present status of manufacturing enterprises in the canal towns and cities is pathetic. From the inception of work on the Erie Canal until forty or fifty years ago this region offered higher rewards to ambition than any other locality, enjoying the cheapest and most convenient transportation facilities. Since the Erie Canal lost its pre-eminence as a carrier, through the development of railroads, while it remained unimproved, and rates in discrimination against short hauls have been imposed, the advantages offered by cheap transportation to other localities have worked injury to the interests of the center of the State. Mr. North.

This fact has been recognized as to agricultural lands for some time. The twelfth census shows that in seven cities of 25 000 or more inhabitants in the center of the State, viz., Troy, Albany, Schenectady, Utica, Syracuse, Rochester and Auburn, all the cities of that class in the interior of the State, the rate of increase since 1880 has not been quite 52%, one city showing an absolute loss. The City of New York, with the dependent cities in this class, Jersey City, Newark, etc., show a gain of 81%; while the twelve cities on the Great Lakes, which have over 25 000 each, show a gain for the twenty years of 168.5 per cent. So low have our canal towns fallen in the estimation of some that they regard any attempt to relight the fires in their abandoned factories, or rebuild their ruined smelting furnaces as an attack on some inexorable law.

It is not proposed at this time to labor with the education of those who have been taught that production at one locality is always at the expense of another, and that the relative, to absolute, decline in value and population of the country along the line of the Erie Canal has aided the development of either the City of New York or the cities on the Great Lakes, but simply to assert the conviction that if the center of this State had continued the rate of development attained in the early canal period, both the lake front cities and New York would offer even higher prizes to ambition than under present conditions.

About two-thirds of the coal produced in Pennsylvania is mined east of the line of equal distances between Cleveland and the head of Seneca Lake. This should give shipping ports at the heads of Cayuga and Seneca Lakes the control of the anthracite trade of the upper Lakes, the control of all coal shipments to Lake Ontario and the upper St. Lawrence, and allow these ports to mediate effectively in the coal trade of the Atlantic coast.

The important influence of this proximity of coal on the manufacturing potentiality of this State, when combined with cheap and ample transportation, and particularly to that portion of the State

Mr. North. which has been so carefully excluded from all plans for a ship canal cannot easily be overestimated. Over 50% of the tonnage on the canal at present is local, and under improved conditions it is possible, if not probable, that the same proportion of any traffic will be stopped either for consumption or to be reshipped with advanced value from manufacture.

At a deep waterways convention it was asserted by the President of the Lake Carriers' Association that two-thirds of the freight passing Detroit was on its way to be advanced in value by manufacture. If we can expect 80 000 000 tons to pass Detroit by the time Lake channels and the Erie Canal could be deepened to 30 ft., and that the tendency to advanced manufacture on the Lakes is offset by the increased production of low-value goods due to cheaper freight rates, the average value per ton remaining as in the past, $11.14, the aggregate value transported will be $891 000 000. So moderate an assumption as that the two-thirds to be manufactured would be doubled in value by that process gives an ultimate value of $1 188 000 000 for the portion under consideration. If 65% of the increased value went to labor, it would employ 772 000 men at $500 a year; this would, as usually computed, support a population of over 3 500 000.

If one-third of the advance in value to Lake freightage by manufacture was given along the canal and in the City of New York, an addition of 1 200 000, or 17% to the population of the State would ensue, and to that extent would increase the local markets of our farmers. As the average capital of the inhabitants of this State will probably be shown by the present census to equal $1 250, such an addition to our population would increase the wealth of the State by $1 500 000 000. If the foregoing figures are approximately correct, the opinion that a ship canal should not "receive any serious consideration from the State of New York" might be sufficiently revised to permit further examination of the subject.

It is difficult to make an estimate that will be satisfactory to all, covering the proportion of Lake commerce which will enter a canal of sufficient cross-section: to be retained for consumption or manufacture in the State of New York, to be distributed to points in Pennsylvania and Lower Canada, or along the Atlantic coast, and to be exported. The City of New York and its environs could easily furnish capital and labor to absorb any possible increase of raw material offered for manufacture. The superior advantages presented by both banks of the enlarged canal from Buffalo to Albany would possibly give it a larger percentage of the total traffic than the present canal does, viz., 53 per cent. And the fact that 80% of the entrances and clearances at the port of New York are in the domestic trade, may justify an expectation that about half of the Lake freightage would enter or pass through the canal.

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Although all sorts of statements have been made asserting the unsuitableness of vessels with a draft of 8 ft. and more, even in deepened lake channels, no one is known to have had the temerity to put a limit on the growth of the Lake traffic, and it would evidently be unwise to construct a canal too small to carry a traffic of less than 40 000 000 tons with the economy dependent on speed and convenience. An approximate estimate of the cost of such a canal, without reference to deepening the Lake channels, may be made by subtracting Mr. Wisner's $27 000 000, the cost of deepening the Lake channels, from the before-used $317 284 348, and adding 50% for building the canal through the United States. At 3% interest and 0.5% maintenance, the annual charge would be, say, $15 250 000.

If a probable ton-mile rate of 0.8 mill is accepted as fair for Lake freights—and for 1898 the average rate was 0.79 mill—and a retardation of 50% for the entire distance of 500 miles between Buffalo and New York is assumed, the freight charge should be 60 cents per ton.

If, on the other hand, a railroad rate of 3 mills per ton-mile for the 440 miles between Buffalo and New York is taken, the cost will be $1.32, making a difference of 72 cents per ton. At this rate, the transit of less than 22 000 000 tons would be required to directly pay the country for the expenditure. This amount is less than the average freight through the Soo for the three years ending with 1899. Obviously, to contend that, neglecting entirely all incidental benefits, there could be any loss to the country by constructing a 30-ft. canal through the State, it is necessary to show that either the estimate of cost is too low or an insufficient allowance for retardation has been made.

As the decisive element in this discussion hinges on the relation between the possible cost of a deep waterway from Chicago and Duluth to the Port of New York, and the probable saving in the cost of transporting the immense volume of freightage to be developed by the improved waterway, indulgence is asked for the presentation of another postulate: If it is thought that the previous estimate should be doubled to cover all contingencies, instead of having 50% added as before, the annual charge would become $22 190 000. Assuming that the expected 80 000 000 tons on the Lakes were carried the present average distance at a saving of 0.25 mill per ton-mile, it would leave $5 650 000 to be earned on the canal. If there was no larger saving per ton carried in the canal than the cost of transferring package freight at Buffalo, viz., 27.1 cents per ton, as mentioned by Major Symons, it would require only 21 000 000 tons to pass through the improved canal to repay the country the interest and maintenance on the entire outlay.

The above-estimated cost is supposed to be greatly in excess of any necessary expenditure, and, in view of the fact that the Government is borrowing money at 2%, the allowance of 3.5% for interest and

Mr. North. maintenance will be thought sufficient. Deepening the Lake channels from 16 to 21 ft., and enlarging the locks, has resulted in reducing freight rates from 2 to 1 mill, and it is not probable that anyone will contend that a further deepening from 21 to 30 ft. would not force a greater reduction in rates than ¼ mill. The only ground for attacking the estimate appears to require a prediction that our producing, manufacturing and consuming capacity is about to be paralyzed.

Although a very large sum, compared with the cost of preceding public or corporate improvements, will be required for this work, it is suggested that there is no necessity for a partial improvement. The United States has not only abundant credit, but the necessary capital in hand to carry the enterprise to a prompt completion. And it is confidently predicted that in no year will the expenditures on this improved waterway exceed our loans of the current year to foreign countries,—loans that aid them in industrial competition.

In a paper on the Suez Canal, lately read before the Institution of Civil Engineers, London, by Sir Charles Hartley, it is stated that questions addressed to many captains and pilots navigating that canal showed a consensus of opinion in favor of a canal that could pass vessels at a speed of 8 knots—9.22 miles—per hour. For this, 3 to 3½ ft. under the bottom of the vessel, with 1½ clear beam widths between vessels when passing, and 40 ft. between the vessel and the bank was desired, with an ultimate depth of 32 ft. 9 ins.

The present scheme for enlargement provides for a depth of 29 ft. 6 ins., a bottom width of 200 ft., or a cross-section of 8 075 sq. ft. Mr. Lionel B. Wells wrote, in discussion of that paper, that with a vessel said to have a speed of 11 knots in the open sea, he made 8 knots per hour in the canal. The cross-section of the vessel was 819 sq. ft., and the probable cross-section of the canal 5 384 sq. ft., or about 6½ times the cross-section of the vessel.

The Bureau of Statistics, in its "Miscellaneous Tables," gives the mean duration of passage of vessels navigating the Suez Canal by night and day as 17 hours 16 minutes, or an average of 5.8 miles per hour, including the necessary delays at "gares," as often as vessels meet.

It is noticeable that a depth of 29 ft. 6 ins. is being obtained, and a depth of 32 ft. 6 ins. is expected in a canal that for some time has not had half the traffic of The Soo, and probably will never pass one-fourth of the traffic of the Detroit River. The paper of Sir Charles Hartley, with the discussion, strengthens the general conviction that the speed of boats in contracted channels increases faster than the ratio of the cross-sections of the channels to that of the boats; and any desired speed can be maintained in a canal of sufficient size. The remarkable absence of accidents delaying traffic in the Suez Canal gives strength to the theory that accidents are less to be dreaded in

canals than in comparatively short passages of restricted width in the course of a free navigation. And it should be remembered that while a small canal is impracticable for a large vessel, the small vessel moves with less expense than in a more contracted channel. Mr. North.

It seems that with a channel of sufficient cross-section to conveniently accommodate the tonnage which may be fairly expected, the saving in the cost of the freight carried will more than pay the assumed rates of interest and maintenance. And that, without regard to indirect and collateral benefits, the investment will afford a profit to the public after paying interest and maintenance charges.

With these considerations, it does not seem entirely proper to imagine a canal of inadequate capacity and predicate on that conception the necessity of high freight rates because of a speed of "only 5 miles per hour."

The very full and complete statistics kept by the engineer corps at The Soo, which cover the last thirteen years, show that concurrently with deepening and enlarging the Lake channels, and, it is confidently thought, in consequence of such deepening, the tons carried in 1887, 5 494 649, increased to 25 255 810 in 1899, while the cost for such carriage increased from $10 075 153 to $21 959 707. A very important relation of this traffic to the production and wealth of the country is shown by the fact that, while the value per ton was $13.83 in 1887, reaching its minimum, $10.59, in 1895, and averaging $11.14 for the thirteen years, the cost of transportation, compared with the value of the freight, has decreased from an average of 10.88% for the three years ending with 1889, to 6.34% for the three years ending with 1898, having averaged for the thirteen years 7.84% of the value of the goods transported an average distance of 827 miles.

It is unnecessary to explain the effect of this low freight rate on the production and wealth of this country, much of the produce having been sold on Lake Erie docks for less than the railroad charges between the points of production and sale, according to E. S. Wheeler, M. Am. Soc. C. E., for some time superintendent of the locks at The Soo. The cost of transportation by railroads would probably have prevented the production of fully half the freight carried, as they would have left only about 45% of the value to the producers. And the low freight rates on the Lakes have been an important if not governing factor in our ability in the nine months ending with September 30th, 1900, to sell manufactured goods valued at over $338 000 000 to foreigners. During the period under consideration the total value of the 169 333 701 tons passing through The Soo was $1 986 374 573, and $155 798 436 was received for its carriage on the Lakes. If this ton-mileage had paid railroad rates, it would have cost over $1 000 000 more. This sum applied to the total expenditures of the country for rivers and harbors—$320 000 000—gives a very satisfactory dividend.

Mr. North. Comparing the railroad rates of 1899 with the water rates, there is a saving of $129 715 811, or a dividend of 40.5%, on the above-mentioned expenditure.

It is recognized that objections are made to taking the average of all railroad freights in comparison with water rates on lower-classed goods, but as a rough measure the method may be inadequate, in view of the facts that the tonnage through The Soo is about half of the traffic on the Great Lakes, and our average freight rates, which are less than half those of any other country, are declining rapidly. This is due more to the competition developed by our ample Lake channels than to any other cause. If the entire cost of transportation must be taken in some proportion from the resources of both producer and consumer, it is probable that the direct gain to the people served by the enlargement of the locks and channels during the last thirteen years is greater than $2 000 000 000, rather than less than $1 000 000 000. This is in addition to indirect gains from the employment given in producing such part of the $1 986 374 570 as was made possible by low freights and the consumption consequent on such production.

History takes no cognizance of an occasion when a proposition to enlarge channels of distribution and cheapen transportation has been submitted to the public without decided opposition to the project from those having an interest in existing transportation facilities. Most of us remember the Lake Carriers opposition to General Poe's plan for a 20-ft. navigation, and Thomas C. Keefer, Past President of this Society, in a paper—"The Canals of Canada"—read before the Royal Society of Canada in 1893, has preserved a record of some of the influence brought to bear on a Commission appointed by the Dominion Government in 1870 to decide on the depth of the Canadian Canal system.

A ship owner, of Oswego, thought vessels 200 ft. long with a burden of 750 tons "ample for the internal commerce of the Lakes, the Lower Provinces and New England; longer locks would cause expense, a strong current and delay, not warrantable in order to provide for a few and rare cases where large vessels would desire to pass to and from the ocean."

Another, "whose life had been spent in the commerce of the Lakes" said:

"It had been clearly established that vessels of over 700 or 800 tons were not so profitable on the Lakes as vessels of a smaller size. Nature has placed barriers in front of most of our harbors, also wide flats across some of our greatest thoroughfares, that will, in spite of art, for ages to come, make it necessary to build lighter-draft vessels. Sail vessels of over 800 tons could not safely navigate the lakes even if harbors were deep enough."

Mr. Keefer does not make it entirely clear whether this testimony is preserved to palliate the insufficient size of the Canadian canals, or

to show the exuberant imagination developed by the possession of some small wooden schooners, in the minds of otherwise reliable citizens. The conclusions and opinions reproduced bear a striking resemblance to some published thirty years later by the Committee on Canals of New York State. Mr. North.

Notices of large-sized steamships which have been built lately, for as certain an ocean trade as that on the Great Lakes, seem to be responsible for a theory that all over-sea commerce is carried in ocean leviathans, and that if we cannot have ocean leviathans we cannot trade. But the sea-borne exports from the United States are carried in vessels that average 818 tons net register; 32 108 vessels with an aggregate of 26 265 976 net registered tons cleared from our ports in the foreign trade during the fiscal year 1899. The average register of sailing vessels was 371 tons, and of steamships 1 064 tons. As a matter of comparison, the American sail vessels passing through the locks at The Soo during the calendar year 1899 averaged 944 net registered tons, and the American steamers 1 162 tons, or nearly 9½% greater tonnage than those engaged in our foreign trade. And the vessels, sail and steam, carrying our exports to foreign countries averaged only three-quarters of the tonnage of our vessels carrying between Lake Superior and the lower lakes.

The steamships out of the Port of New York, in our export trade, averaged 2 324 tons; those to English and European ports north of Gibraltar, 3 055 tons. To the Mediterranean, the average was 2 104 tons; to South American ports, 1 517 tons, and to West Indian ports, 1 453 tons.

The greater average tonnage to ports north of Gibraltar is due in part to their larger consumption, and in part to our necessity of shipping *via* those countries whose persistent subsidies to steamer lines has enabled them to become distributors of the goods of less alert nations to those small but more profitable markets which are not reached by direct lines from this country.

Although there is no doubt that the large vehicle with full loads always carries freight at a lower cost than the smaller one, the small carrier is necessary to commercial development and occupies the same position to ports of smaller production that our cheaply constructed railroads of the '40's and '50's held in the development of this country. A large commerce is as impossible without development by the small carrier as the four-tracked railroad would be without its forerunner, the cheap road.

Much has been said about barge and other towing on the Lakes, the Atlantic and on rivers. Towing on the Lakes, though theoretically economical, has not proved sufficiently profitable in practice to receive much development. The peculiar fleet-towing on the Ohio and Mississippi, viz., the towboat pushing the fleet or holding back in

Mr. North. bends, gives probably the cheapest transportation known, but that method would be impossible on the Lakes, of doubtful practicability on any canal, impracticable in a stream like the Hudson, where the tide ebbs and flows from New York to Troy, and would be dangerous at times in the Tappan Zee with the style of boats used on the Ohio. String and fleet-towing are both practicable on nearly all rivers, and there seem to be no theoretical objections to its economy; but, excepting fleet-towing on the Hudson, it has not been much developed in this country.

String-towing has for some time been practiced both on the Lakes and ocean, particularly in the coasting trade. At one time the large coal railroads moved substantially all of their coal to eastern ports by towboats and barges. In the dark days between 1893 and 1897 it was thought the coasting schooner was doomed. It is asserted that for one year only one schooner was launched in eastern ship yards. That is now ancient history. For some time there has not been a vacant berth in an eastern yard. A list of this year's launchings shows eighteen 4-masted to 6-masted schooners, averaging over 1 700 tons gross register each. The coal companies will doubtless continue towing barges along the Atlantic coast, but it is doubtful if that method of transportation will again attain the relative importance of four years ago; it, however, does not seem likely to be discontinued, and will probably always present a means of cheap transportation.

Fear is felt by some that foreign governments would subsidize steamer lines to our Lake ports and not only capture the trade of the Lakes, but destroy the ship-building industry established there. Such fear does not seem well founded. No vessel under a foreign flag could do a way business between any ports in the United States, and, though a few foreign steamers would discharge and load cargoes at Lake ports, their entire participation in that traffic would probably not exceed the 2 to 4% of British tonnage now passing The Soo. But it can be confidently predicted that, with a practicable channel to the sea, there are few vessels which would not add to their cost the 8 to 10% necessary to put in condensers and enable them to compete for the very high ocean freight rates now exacted, which are substantially paid by our producers.

This theory, that either American carrying or American ship building would be injured by an ample waterway connecting the Lakes and ocean together, has great doubt thrown upon it by the attitude of the agents of foreign steamships sailing from our ports and that of their employees and other servants. These lines are generally subsidized by the governments whose flag they fly, governments that know what they are paying their money for, and their agents in this country must uphold the interests of such governments, as well as the interests

of the stockholders and those of the closely affiliated railroads in this country, or make way for some one better fitted for the position. It is doubtful if, in the whole category, a single advocate for anything larger than a barge canal can be found. And the fear that a ship canal of ample cross-section would enable these foreign shipowners to increase or even maintain their present high rates for freight and passengers seems to have no more foundation than a fear that the same canal would allow the New York Central to maintain either its general freight rates or its discrimination against the profits of our wheat growers. Mr. North.

The importance, to our national prosperity, of our present low freight rates and their further development in this direction cannot be overestimated. Any history treating of national power, from the dim days when its seat lay on the Euphrates route between India and the then West, to the present, shows, probably without assertion, that possession of the cheapest and most efficient transportation has been necessary for the greatest development of production and wealth.

Forty years ago Great Britain possessed the cheapest internal transportation, and, while seeing the destruction of our merchant marine, was building up its own with subsidies of nearly £1 000 000 per annum. In the aggregate rewards of its industrial energy it was apparently unapproachable. But the principle of conserving vested rights has enabled the managers of her railways to maintain freight rates without sensible diminution during this period, and prevented competition from enlarged canals. Other nations, however, have enlarged their waterways and reduced freight rates. Then, England stood easily first among the nations and this country third. Now, the United States, having the lowest freight rates, stands first, and there is doubt whether England, whose manufacturers and consumers pay more per ton-mile for transporting their freight than any other people, stands second or third in rank.

The managers of our railroads, unable to establish legislative principles analogous to those of England, except possibly along our northern seaboard, have adopted the expedient known as "community in stock ownership" with the apparent, if not avowed, intention of preventing healthy, or other, competition in the future. Success in this plan will probably result in no further diminution of freight rates in this country, unless there is more effective competition from water routes. Few doubt that the opening of the combined Lake and canal route in the spring still influences, and to some extent controls, all freight rates east of the Mississippi, as they did to a greater extent when Mr. Fink gave his testimony. None can doubt that a larger waterway than the present would have more influence; nor can it be denied that the larger the waterway, the greater the influence exerted

Mr. North. by it. The only tenable question is as to the economical size of the canal.

Approaching the discussion of these papers with a predilection in favor of large channels, that some might call a prejudice, a collation of the figures, presented from year to year by the members of the United States Engineer Corps in charge of the locks at The Soo, showing the important items of the traffic, has resulted in astonishment at the combined growth of tonnage and decrease in cost of transportation, both absolutely and in terms of value carried. They show a traffic that is unprecedented for volume per inhabitant served, and is also thought to be unprecedented in both the small value per unit of commodities carried and in the low cost of the service. This is from a lake, the shores of which were visited by the explorers of sixty years ago.

When the first locks at The Soo were opened to traffic we were a poor nation, and capital for small enterprises was secured with difficulty, mostly from foreigners at money-lender's bargains. To-day we seem to be the world's favorite gathering ground for national loans.

A consideration of the curves of increase and decrease, shown by these returns, and their extensions, have appeared to justify the foregoing assumed increases in tonnage and decreases in cost of service. They also are thought to warrant the prediction that no channel from the heads of the Great Lakes to the Port of New York in the service of distribution between the area which seeks outlet on that channel and the Atlantic coast of our country, will be so large as not to be inconveniently crowded by the passing traffic. The direct returns from the lower freight rates, on an ample and commodious channel, will undoubtedly exceed the annual expense to the nation for interest and maintenance.

As the statistics referred to may not be easily accessible to all members of the Society, they are given in Tables Nos. 8 and 9, with the addition of the railroad rate per ton-mile, as given in Poor's Manual, and some calculated deductions.

There is much reiteration by Mr. Wisner of the statement that 21 ft. limits the economical depth for navigation on the Lakes, but probably not more than was used by vessel owners against the first deepening of the waterways, nor more than was urged against General O. M. Poe's splendid project for the 21-ft. channels. The economic size of the carrier is thought to be governed not so much by the length of haul as by the amount of freight offered, which is probably the most important factor in determining the size of the vessel used. That the present limitation of the draft of vessels on the Lakes is not satisfactory to the business interests of Chicago, may be seen from the 24-ft. channel of their Main Drainage Canal, which was commenced in Sep-

tember, 1892, and has been pushed through rock and earth to a navi- Mr. North.
gable conclusion. This depth, however, apparently does not measure the ultimate ambition of Chicago for cheap transportation, as it seems the Drainage Trustees are proposing to deepen the Chicago River to 30 ft.

TABLE No. 8.—NET REGISTERED TONNAGE PASSING THE LOCKS AT SAULT STE. MARIE (THE SOO).

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.
1855	106 296	1864	571 438	1873	1 204 446	1882	2 468 088	1891	8 400 685
1856	101 458	1865	409 062	1874	1 070 867	1883	2 042 259	1892	10 647 203
1857	180 820	1866	458 530	1875	1 259 534	1884	2 967 837	1893	8 949 754
1858	219 819	1867	556 899	1876	1 541 676	1885	3 035 937	1894	13 110 366
1859	352 642	1868	432 563	1877	1 439 216	1886	4 219 397	1895	16 806 781
1860	403 657	1869	524 885	1878	1 667 136	1887	4 897 598	1896	17 249 418
1861	276 639	1870	690 826	1879	1 677 071	1888	5 130 659	1897	17 619 933
1862	359 612	1871	752 101	1880	1 734 890	1889	7 221 935	1898	18 622 754
1863	507 434	1872	914 735	1881	2 092 757	1890	8 454 435	1899	21 958 347

Lock.	Dimensions.	Date of opening.
First lock; double lift.....	350 × 70 × 11½ ft.	June 18th, 1855.
Weitzel lock.....	515 × 80 × 17 ft.	Sept. 1st, 1881.
Canadian lock.....	900 × 60 × 20 ft.	Sept. 9th, 1895.
Poe lock.....	800 × 100 × 21 ft.	Aug. 3d, 1896.

NOTE.—Deepening the lake channels from 16 ft. to 21 ft., which was commenced in the spring of 1893, is not yet fully completed.

No other demonstration, of the results which will accrue from larger channels, is possible than the increase of tonnage and decrease of freight rates which have followed increasing the depths in The Soo locks from 11½ to 21 ft. Nor should any other be required. Anyone who, 20 years ago, had predicted that the 2 000 000 tons then passing The Soo would expand in the year 1900 into 25 000 000 tons would have been considered of unsound mind. Then, Minnesota, the two Dakotas, Wyoming and Montana, with an area slightly less than 500 000 sq. miles, had a population of 2 per square mile; now, the population is 6. And, though we may not predict another increase of 200% in the next twenty years, a much larger absolute growth is certain if a continued decrease in freight rates is maintained. The same statement seems authorized as to the traffic. The traffic and population being interdependent, and both dependent on the freight rate, their development will be governed by the size of the Lake channels.

The minimum depth on the miter-sills of the next lock built will be 24 ft., and it is possible that the depth will be 30 ft.

It may be doubted if the expected and desirable change in the character and value of materials exported will result in a decreased

Mr. North.

TABLE No. 9.—Traffic through the Locks at St. Mary's Falls, otherwise called "The Soo."

Year.	Tons carried.	Ton-miles.	Average distance.	Lake cost of carriage.	Cost per ton-mile.	Average railroad freight rates per ton-mile.	Railroad cost for equal ton-miles.	Total value of freight carried.	Value per ton.	Percentage of value paid for transportation.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
					Mills.	Mills.				
1887........	5 494 649	4 458 544 804	811	$10 075 153	2.3	10.34	$46 101 353	$79 031 757	$13.83	12.75
1888........	6 411 423	5 173 132 972	806	7 883 077	1.5	9.77	50 541 509	82 153 019	12.81	9.59
1889........	7 516 022	5 940 646 352	790	8 634 247	1.5	9.70	57 624 270	83 732 527	11.14	10.31
1890........	9 041 213	7 207 299 415	797	9 472 215	1.3	9.27	66 811 666	102 214 948	11.30	9.26
1891........	8 858 759	7 292 462 269	820	9 849 023	1.35	9.29	67 746 974	128 178 208	14.42	7.68
1892........	11 214 333	9 222 773 938	822	12 072 851	1.31	9.41	86 786 303	135 117 267	12.49	8.93
1893........	10 796 572	8 980 310 240	832	9 957 483	1.10	8.93	80 194 170	145 436 957	13.47	6.84
1894........	13 195 860	10 927 871 324	821	10 798 310	0.99	8.64	94 416 808	143 114 502	10.80	7.54
1895........	15 062 580	12 502 548 892	830	14 238 758	1.14	8.39	104 896 385	159 575 129	10.59	8.92
1896........	16 239 061	13 582 641 886	836	13 511 616	0.99	8.21	111 513 490	195 146 842	12.02	6.87
1897........	18 982 755	15 969 393 576	841	13 220 100	0.83	7.97	127 276 067	218 235 927	11.49	6.06
1898........	21 234 664	17 891 597 030	843	14 125 896	0.79	7.58	135 618 305	233 069 740	10.98	6.10
1899........	25 255 810	20 891 944 628	827	21 959 707	1.05	7.26	151 675 518	281 364 750	11.14	7.80
Totals and averages.	169 333 701	140 041 167 326	827	$155 798 436	1.11	8.43	$1 181 202 818	$1 986 374 573	$11.14	7.84

aggregate tonnage of exports. For thirty years we have been steadily bringing the factory nearer to the producer of raw materials, with a concurrent phenomenal increase in freight tonnage, although, theoretically, the process should diminish the ton-mileage of the country. Mr. North.

Undoubtedly, "a waterway from the Lakes to the Atlantic should have dimensions which will permit the passage, at economical speeds, of ships best adapted for the traffic of the water routes connected;" and, "it should be the one best adapted for the distribution of products and manufactures for domestic uses." The first of these assertions calls for a waterway that will connect the immense power of production in the area tributary to the Lakes, not only with our Atlantic and Gulf Coast ports, but with all ports fronting on the ocean; and it will not be denied that the larger the waterway the less the cost of transportation through it. The second will lead to the location of the waterway near the line of the present canal, where it will feed and develop our central aggregation of population and capital.

Attention is once more asked to Mr. Corthell's figures for the tonnage of the Port of New York. He found the entrances and clearances in the foreign trade to be 15 201 653 tons, and in the coastwise trade 25 093 000 tons; that is to say, the volume of the foreign trade of New York is less than 61% of the coasting trade. But to both of these trades the canals of the State of New York contribute only about 3 000 000 tons. We have no standard which enables us to correctly predicate the tonnage of the harbor when the Erie Canal contributes 30 000 000 tons instead of 3 000 000.

The statement that 40 000 000 tons passed through the Detroit River was, in fact, taken from Mr. Mayer's paper, and erroneously credited to Mr. Wisner.

Thomas Monro, M. Inst. C. E. (by letter).—Mr. Wisner makes out a fair case for a 21-ft. channel, but the writer must take exception to the way in which he has bracketed the "decline of traffic on the Erie Canal since 1880," with the alleged "failure of the 14-ft. Canadian canals to divert commerce from the lake and railroad lines." It is true that the traffic of the Erie Canal, at its present dimensions, is constantly declining—and for obvious reasons—but the 14-ft. channel between Lake Ontario and the sea has not yet been tried, and, therefore, cannot correctly be said to have failed. As is well known, the Canadian canals were only fully opened to the new dimensions this spring, and there are as yet but few vessels of full "Canadian canal size" in existence. The fleet that can navigate the St. Lawrence route to the greatest advantage has yet to be built, but the writer believes that a number of suitable craft are now in hand on the Upper Lakes. As a matter of fact, only one vessel drawing 13½ ft. passed through to Montreal, so far, this season. The writer is inclined to believe, however, that the $65 000 000 spent by Canada on a line of navigation Mr. Monro.

Mr. Monro. which will enable vessels drawing 14 ft., and carrying from 2 000 to 2 200 tons, to pass directly from Duluth, Fort William or Chicago to Montreal without breaking bulk, has not been entirely thrown away—but, on the contrary, this magnificent route, when fully developed, as it will be ere long, must prove a valuable means of transporting grain, ore, steel, etc., for export to Europe *via* Montreal.

If the arguments set forth in Major Symons report of 1897 are correct (and the writer believes this to be the ablest and most practical paper which has so far been written on the subject), and his conclusion sound, that the best thing New York can do is to construct a 10-ft. barge canal across the State 350 miles from Buffalo to Albany, then there appears to be a chance for Canada to do some business, on a 14-ft. basis, with boats of 2 000 tons, and only about 70 miles of canals between the Great Lakes and the seaboard. Of course, it is a fact that the domestic commerce of the United States, between the centers of population in the East and the producing regions of the West, constitutes the vast bulk of the present traffic; and the Canadian route does not lead directly either to the New England States or New York; but the development of Canada's own vast areas of production in the Northwest must soon give plenty of work to do. There will be enough to crowd all the avenues of transportation both by rail and water. The railways are making such rapid strides in cheapening freights that the water routes will have to look to their laurels. Brindley said that rivers were made to feed canals; but one would not now be surprised to hear of railway men proposing to fill them both up so as to form roadbeds for their ever-multiplying tracks. If the water routes fail entirely, as has been so confidently predicted, the Canadian route cannot prove the exception hoped for. At all events, Canada is past the theorizing stage. Its main canal system is now completed, such as it is, and, if it fail, all that can then be said for Canadians is that they deserve more credit for pluck than for foresight. However, the end is not yet, and the writer, for one, fully believes that Canada will, in due time, reap the full benefits of her large expenditure on her national route.

Mr. Hinds. FRANK A. HINDS, M. Am. Soc. C. E. (by letter).—Mr. Wisner's paper is valuable in that it shows the necessary dimensions a canal must have in order to do a successful business between the Great Lakes and New York, and Mr. Mayer's paper throws much light on the question of who should build it.

That the enterprise belongs to the United States and not to the State of New York alone, becomes more evident the more it is considered, although New York State will always be much interested in it, on account of its necessary location through her territory.

Nature made a great valley through the middle of New York State, cutting the Appalachian system of mountains below the level of Lake

Erie and making it possible to construct a self-supplying waterway from this lake directly to tide water at Troy on the Hudson. In the report of the Deep Waterways Commission of 1897, this route, although mentioned, was not reported with favor, but, instead, a route was mentioned from Lake Erie to Lockport and to Lake Ontario at Olcott Harbor, and thence by way of Lake Ontario to Oswego and up again through the Mohawk Valley and finally down to Troy. The reasons given in favor of the Lake Ontario route were: Less standard canal to build; the development of new business on Lake Ontario, and a supposed saving in total length. Mr. Hinds.

It would seem now, however, in view of the comparative speed which a vessel may be able to make in the canal, as is shown in the two papers under discussion, and also in view of the expense and difficulty of providing an adequate and reliable water supply for the summit of the Mohawk Valley Canal, that the subject of a self-supplying, continuously-descending-grade canal from Lake Erie to the Hudson should have further consideration.

The level of Lake Erie is 573 ft. above tide; that of Lake Ontario 247 ft. The long Rome Level of the present Erie Canal is 430 ft. above tide, or 183 ft. higher than Lake Ontario. Of all the business to be done on a waterway, probably more than seven-eighths would come from Lake Erie or points farther west.

Now, if, as recommended by the Deep Waterways Commission in 1897, the route is from Lake Erie through Lockport and Olcott to Lake Ontario, and thence by Oswego and Oneida Lake to Rome, all the through tonnage must be lowered to the level of Lake Ontario and then raised again to the Rome Level, making, as compared with a continuous-down-grade canal, twice the difference in level of 183 ft. from Lake Ontario to Rome, or 366 ft. of unnecessary lockage.

A new canal would, of course, be made with fewer locks and greater lifts than was the old practice, but the delays consequent upon 366 ft. of lockage would offset any advantage of greater speed to be made by vessels while in the open lake between Olcott and Oswego. The time required for this 120 miles of lake navigation at 12 miles per hour would be 10 hours, while in the standard canal, at 8 miles per hour, it would take 15 hours, or 5 hours more than on the open lake; but this would be a short time in which to accomplish the 366 ft. of unnecessary lockage. A comparison of the total distance over each of the two routes, although it cannot be made with certainty until each is carefully surveyed, would probably not disclose a great difference between them; but the probabilities are, judging from a study of the topographical maps of the United States Geological Survey, etc., that the shorter line will be found to be by way of the continuous canal.

With the continuous down-grade, the water from Lake Erie would practically supply the canal through to the Hudson, and avoid the

Mr. Hinds. very difficult problem of providing an entire water supply at the Rome Summit.

It is to be remembered that, where a canal passes over a summit, the water must be supplied at the top, and each boat in passing over requires a supply of water equal to the horizontal size of the lock multiplied by the total height of all the locks ascended or descended.

A ship canal passing over the Rome Summit Level, from Lake Ontario to the Hudson, requires a total lift of $183 + 430 = 613$ ft., and all the water for operating the locks in either direction must be supplied at the summit.

It was proposed, in the Deep Waterways report, to make a moderate development of the canal through western New York, with a high level from Newark to Syracuse, as a means of water supply for the Mohawk Valley Summit.

Now, if it is practicable to make a feeder along this line, then it cannot be very impracticable to make the feeder into a canal, and the cost of the first construction, and the maintenance of this feeder afterward, can be applied in the first cost of the continuous canal, which will be self-feeding. Lake Ontario may be fully accommodated and its interests as thoroughly developed by a side cut, probably through Oswego and the Oswego River, as it would if all the business from the Upper Lakes was compelled to pass down to its level and then be raised again over the summit.

With the necessary water supply reduced to a minimum, and it takes much less water for the through business if the unnecessary lockage into Lake Ontario is avoided, and with the supply of water coming from a source as constant and secure, and as well situated, as that of Lake Erie, it is plain that this route deserves more attention and consideration than it seems to have received.

With the work in the hands of the United States Government, it can certainly afford, if it builds a canal, to build the one that is best and most desirable for the whole country, and cheapest and simplest to operate.

Mr. Sweet. ELNATHAN SWEET, M. Am. Soc. C. E. (by letter).—These papers, relating to the same propositions, and reaching similar conclusions, deepen the conviction the writer has held, ever since bringing this subject to the attention of the Society, in a paper read at the Buffalo Convention in 1884,* that no waterway built to connect these waters can hope to secure great commercial importance unless it can accommodate the largest vessels navigating the Great Lakes.

In a communication to the *Times*, opposing the endorsement of the proposition then before the people of New York to authorize the expenditure of $9 000 000 for slightly enlarging the State canals, the writer urged that "the expenditure of great sums of money for so-

* *Transactions*, Am. Soc. C. E., Vol. xix, p. 37.

called improvements of the present canal were to be discouraged as wasteful, and because they tended to postpone the wise and statesmanlike undertaking of a deep-water outlet for Lake commerce." Mr. Sweet.

There are three fundamental and controlling elements of advantage in the deep waterway:

First.—The elementary physical law, that the resistance to motion in vessels of like model varies directly as their immersed surfaces, while their tonnage varies as the cubic contents of their immersed section, ensures enormous economy in large boats.

Second.—The obvious and controlling advantage of passing from terminal to terminal without transfer of cargo.

Third.—A large fleet adapted to the navigation of the deep waterway already exists, while, to put the smaller canal into operation, a new marine equipment must be created, for which there could be little use elsewhere.

Mr. Wisner makes a very strong argument, showing the disproportion of benefit to cost in the deepening of Lake channels and harbors beyond the depth of 21 ft., now in process of attainment by the Government engineers. This seems to the writer to afford definite authority for fixing the depth of the canal, and, in the light of the extended experiments made since 1890 in France and Germany on the resistance to traction in narrow channels, the writer thinks that the making of the wet cross-section more than five times as great as the midship section of the largest vessel it is intended to accommodate, will insure about two-thirds of the speed secured in open water with the same expenditure of energy; but for economy of movement with 19 ft. draft he thinks that the proposed form of section should be modified by increasing the depth 2 ft. and narrowing the width sufficiently to secure the proposed sectional area of channels. He cannot share the sanguine expectation expressed by Mr. Mayer as to the volume of tonnage likely to soon seek transportation on such a canal. Its chief function will be the transportation of freight destined for Atlantic ports and for export. The ore and coal freights which form so large a fraction of lake tonnage cannot, under present conditions, contribute business to this canal.

It must be remembered that the railroads are the natural and necessary distributors of even the coarsest and heaviest freight, as their side tracks reach the yards of all large manufacturers and consumers throughout the country. A large part of the tonnage received by lake at Buffalo and other Lake Erie ports is destined for distribution in the interior of the Eastern-Middle and New England States, and this freight will all probably continue to be handled from Lake ports by the railroads, for the reason that the branch roads making this distribution are controlled by railroads reaching these Lake Erie ports, and their control of local rail rates will enable them to route this busi-

Mr. Sweet. ness through from these ports instead of from points farther east on the canal.

There is a question of public policy to be considered as to the effect of withdrawing so large a part of the business of the railroads, in which so large a part of the capital of the country is invested, upon their earning capacity and the rates it would be necessary for them to impose on their remaining traffic.

Account should also be taken of the question whether all freights may not ultimately be handled more cheaply by rail, in favor of which there are both practical results and theoretical considerations.

The great and uninterrupted decrease in unit-cost of railroad freight transportation during the entire period since its introduction may be cited as the practical result, and the fact that the resistance to the movement of rail freight varies directly as the velocity and on account of the labor item is (within limits of safety to track and equipment) cheaper at high than at low speeds, while the resistance of vessels increases at a rate greater than the square of the rate of speed, and is absolutely greater than the rail resistance except at a moderate rate, may be urged as the principal theoretical consideration.

The fact that our resources are growing so rapidly, that the Lake Region and the line of this canal furnish the most suitable field for a great export business in heavy manufactures, and that the export freight business is necessarily carried on by water, make it probable that both the railroads and the canals will be needed in a future not remote, and both be profitable.

Mr. Hunter. W. HENRY HUNTER,* M. Inst. C. E. (by letter).—In responding to the invitation to take part in the discussion of a subject of such world-wide importance, the writer can but express his regret that lack of time and pressure of official engagements have rendered it impossible for him to find opportunity for the close and detailed study of the question which is rendered so necessary by the great issues involved in it, or to grasp anything more than the outlines of the different schemes which have been propounded; though in this particular the papers by Messrs. Mayer and Wisner have been of the greatest possible assistance.

It appears very clear, to many outside the boundaries of the United States, that the time has arrived in which it is essential, even in the interests of their own country, that the economists and engineers of the United States should take more practical cognizance of the fact that their great Republic has an even more important part to play as an integral portion of the human family, than as a more or less self-contained community (or concourse of communities) dwelling alone, devoting itself to the development of its own resources, and the advancement of its own interests, whether material or moral.

*Chief Engineer to the Manchester Ship Canal; President of the Manchester Association of Students of the Institution of Civil Engineers.

Mr. Hunter.

The date of the accomplishment of the poet's dream of "The parliament of man, the federation of the world," is as far off as ever; yet, of nations as of individuals, it is true, and is becoming more and more apparent, that "No one . . . liveth to himself, and no one dieth to himself," for the interdependence of humanity is growing more and more pronounced as population increases, and as the reserves, in the way of uncultivated prairies and unwatered steppes, are being brought into use for the benefit of man.

Interdependence involves intercommunication: The one is a question for the economist, the other a matter for the engineer; the present danger is that in each case too narrow a view may be taken, either of the responsibilities of the position, or of its possibilities.

The problem of the future, the not-far-distant future, will resolve itself into the broad question of the supply of food to the rapidly increasing masses of mankind. Civilization is becoming effective at last, and the result is that population is growing at an unprecedented rate, so much so that the academical question—the question of the theorists—of former generations, as to the sufficiency of the earth for the support of her children, will soon loom largely on the horizon of practical politics, and men will have to rouse themselves to deal with it.

If this were admitted and its significance realized, proposals for constructing barge canals, or even ship canals of insignificant depth, between the Atlantic seaboard and the Lakes which form the natural center of one of the greatest food-producing districts on the earth, would drop into the limbo of "lost causes"; the insufficiency of either one or the other would become so manifest.

The first and greatest of the means of intercommunication on our planet is of Nature's providing, is the ocean; whether in the East or in the West, the sea is the trunk highway for mankind; and the primary object to be sought in the projection of a waterway originating on the seaboard, and consisting, as is generally the case, (*a*) of the improvement of a river, (*b*) of the formation of a canal, should be the carrying of the sea as far into the interior as is reasonably possible; for the farther the sea is carried into the interior, the greater will be the benefit to the district affected, and the more marked will be the ultimate success of the waterway.

The Manchester Ship Canal furnishes an example of a waterway of this class. The terminal docks are 50 miles inland from the coast line, a distance which is covered by 15 miles of estuarial and river improvement, and 35 miles of canal construction, construction which was carried out in the midst of a dense population, in the teeth of bitter and prolonged opposition, and in despite of a crowd of ancient rights and vested interests, which are always short-sighted, inert, and desperately opposed to progress, but which, in a country like Great

Mr. Hunter. Britain, must be reckoned with, must in some cases be conciliated, in others coerced. Either process costs money, hence the Manchester Canal cost more than it should have cost, to which cause, added to that presented by the obstructions thrown in the way of its working by the same vested interests, is due the fact that up to the present time it has returned no reward in the shape of dividend to its original shareholders.

This fact had led pessimistic persons to the conclusion that the canal has failed in the accomplishment of the purpose for which it was promoted and constructed. There never was a greater fallacy, a greater error. A prominent public man in Manchester,* the head of one of the largest manufacturing firms in England, has declared again and again, and has met with no one bold enough to deny his proposition, that the citizens of Manchester are receiving more than 20% per annum for the $25 000 000 which the city invested in the canal, while directly and indirectly the canal has influenced for good a district in which the population is more dense than in any other on the face of the globe, and has sensibly advanced the welfare of some 10 000 000 human beings. At the same time trade is growing, developments are accruing, terminal facilities are being increased and extended, and the cost of handling traffic diminished to such a degree that there is every prospect of a return being made ultimately, even to the patriotic shareholders who put their money into the undertaking.

The depth to which the Manchester Ship Canal was constructed was 26 ft., but the sills of all the locks were put down to 28 ft. Steamers of a dead-weight capacity of 10 000 tons are now traversing the canal regularly, and others, still larger, are projected. Thus it is clear that the deepening of the waterway to 28 ft. will have to be taken in hand at no distant date, for the course of trade is now such that large steamers can run and prove themselves profitable to their owners, where small or even moderate-sized vessels cannot live.

Applying this experience to the case under discussion, which is really not one of carrying the sea inland, so much as it is one of joining two seas, or, in other words, of severing an isthmus, it would appear that a dead-weight capacity of 8 600 tons for the ocean-going steamers proposed to be sent on, *via* the new waterway, to Chicago, would be insufficient. Such steamers would hardly compete now with the large and improved boats which are continually being launched, and in twenty years' time they would be altogether out of the running. If the canal were formed with a depth of 24 ft. in the first instance, and all lock sills, syphons, and other works which would limit the possibility of future deepening, were put down to 30 ft., it is probable that the waterway would meet the world's needs for the next half century, which is all that can be required.

* Mr. Reuben Spencer, the head of the firm of John Rylands & Co.

Mr. Hunter.

The regulation speed of vessels on the Manchester Canal is, as stated by Mr. Wisner, 6 miles per hour, but licenses are issued to steamers permitting them to run at the rate of 8 miles, as experience has proved that at this speed no sensible amount of injury is caused to the banks by wash; the licenses are, therefore, granted as a matter of course, there having been only one instance in which the writer has had to refuse his consent to the issue, and that was in the case of a large paddle steamer (an undesirable craft on a canal), which was already really running at the rate of over 8 and wanted to run 10 miles per hour. There need, therefore, be no apprehension as to the safety of the estimate of 8 miles per hour as the average speed of large steamers on the proposed Lakes Canal.

The writer would like to add one observation in respect of the argument that if the Lakes Canal were really required "the play of economic forces" would be sufficient to bring about its construction. The economic theories—or principles, if the word is preferred—of one age become the fallacies of another, as life becomes more complex, and the interdependence, to which reference has already been made, grows more complete. From this proposition, if sound, it follows that strict adherence to theories as to demand and supply, as if these theories were natural laws which could not be broken with impunity, would inevitably arrest the advance of civilization and the progress of the human race.

The ordinary investor, as such, is neither a philanthropist nor a patriot—he does not think—nor indeed is it possible for him to think, except in a secondary way, of the good of mankind, of which he is a part, or of the welfare of the State, of which he is a subject. On the contrary, his operations are governed wholly by the prospect of return for his investment in the form of interest upon his capital. It is clear, therefore, (1) that public works of the first magnitude—arterial lines of communication and the like—which are, in the first place, for the public benefit, can present little of attractiveness to the investor, (2) that such works will never be made out of private money (any more than ironclad line-of-battle ships can be built, or coast defenses constructed, out of private money), and (3) that, as it cannot be denied that they are a necessity for the public welfare, the public, that is to say, the State, must of necessity provide the funds required for their construction and equipment; and this despite the instinctive tendency of the Anglo-Saxon race to depend in these matters upon private enterprise rather than upon governmental energy.

In the opinion of the writer, the advantages, direct and indirect, which would accrue to the citizens of the United States from the construction of the canal between New York and the Great Lakes would be so profound and far reaching, and the increase of the prosperity of the community would be so marked that the Central Government would be

Mr. Hunter. justified in forming the canal and in throwing it open to the trade of the world at the smallest possible toll charge; he claims that the case of the Manchester Ship Canal, and of the benefit which its working has been proved to have conferred upon the greatest manufacturing district on earth, furnishes a firm basis for this opinion, and he desires to thank the American Society of Civil Engineers and the authors of the papers under discussion for affording him an opportunity of expressing it.

Mr. Hoech. THEODOR G. HOECH, M. Am. Soc. C. E. (by letter).—The report of the New York Canal Commission on a barge canal of 12 ft. depth, and other studies of improved waterways between the Great Lakes and the metropolis on the Hudson River, after the able report of Major Symons recommending a barge canal 12 ft. deep, cannot fail to prove, even to a distant observer, the growing interest of the engineering profession in an improved waterway, and at the same time a sentiment for greater dimensions for this modern canal.

Not being able to check the figures presented, the writer may be allowed to point out some commercial features of North America's Atlantic slope affecting inland navigation.

The commercial power of the City of New York seems to be so great that the exporting merchants do not think of running ocean steamers up the Hudson River with the flood current to meet the canal boats as far inland as possible, as is the case in several European rivers. One could figure out, however, that the cheapest way of exporting western goods would be to carry them by barges or lake steamers, say, to the Hudson, and to transfer them there into large transatlantic steamers. It is to be considered a silent but great compliment to the harbor of New York that nobody advocates this waterway system, promising the cheapest rates from West to transatlantic ports.

New York's attractive and accumulating power seems also to have prevented the commerce from passing in greater degree through the Canadian canals of 14 ft. depth.

That dominant position of New York will, of course, be of deciding effect on the final solution of the waterway question, and the fact should not be overlooked that with a ship canal ocean steamers would pass the metropolis of the Atlantic Coast, and allow European freighters to run into the Great Lakes as far as Duluth, and take the grain of the West to Europe, without transfer and harbor expenses. It does not seem likely that New York will part with the many petty charges and profits derived from distributing and transferring goods.

One may safely presume that the City and the State of New York will construct a waterway satisfactory to their interests, which commercially will be of the same kind as the old Erie Canal—and will strengthen still more the great center on the Atlantic Coast. It is important to the city that all transfers between the Lake harbors and

New York should be done away with, while retaining the transfer business, and this condition can be satisfied by a large barge canal. Mr. Hoech.

In Germany, the number of barges—Seeleichter—is growing rapidly, and these barges run safely from the Rhine and the Dortmund-Ems Canal through the German Sea, and the Kaiser Wilhelm Ship Canal to the Baltic Sea—the Great Lake of Northern Europe. Besides these towed barges, twenty-five small steamers are running regularly from Koeln on the Rhine to London, Hamburg, Dantzig, etc.

The growing sentiment for greater dimensions for new canals may, in the writer's opinion, lead to a barge canal of 14 ft. depth, after some further discussion. This would give a fair field for competition and comparison between small freight steamers and large barges, and the results would be watched with great interest everywhere.

The advantages of a 14-ft. barge canal, which would take care of the business concerned for some time, may be stated as follows:

First, it would mean a great step in advance without changing the commercial position fundamentally, and the canal itself could be constructed in two parts: With a deeper canal from the Mohawk Valley to Lake Ontario in operation, steamers and barges could make use of the Welland Canal, allowing the time for building the Niagara Canal and the fleet of standard vessels.

Secondly, the fleets of steamers and barges would be enhanced in value on account of the two outlets to the ocean, and even a third one from Chicago to New Orleans, which can be hoped for.

Without strong reasons for a change, the dimensions of neighboring waterways, even when a little less profitable, should be accepted. The Canadian canals may keep their present dimensions for many years to come, and the ship canal from Chicago to New Orleans may not come at all, for two reasons. After a ship canal is built from the Great Lakes to the Atlantic Coast, no second ship canal would be needed to the Gulf, for no ocean steamer would choose such a long inland waterway in competition with cheap river steamers and still cheaper barges. But a deep barge canal from Lake Michigan to the Mississippi, and another one from Lake Erie to the Ohio River, would form, with the Canadian and the New York canals, a great system of uniform waterways opening half a continent to steamers and barges of standard dimensions.

Alfred Noble, M. Am. Soc. C. E. (by letter).—The time required for the passage of a ship through the proposed Deep Waterway is perhaps as likely to provoke discussion as any point in Mr. Wisner's paper. The writer, having taken part in the investigation from which Mr. Wisner's conclusion resulted, will present an outline of it. Mr. Noble.

The movement of a ship through the artificial channels of the Deep Waterway would be obstructed by two different sets of causes: 1st. Reduction of speed due to the restricted dimensions and curvature of the

Mr. Noble.

waterway and the meeting of ships therein; and 2d, delays for passage of locks.

Any restriction in a waterway, whether of depth or width, will cause a reduction in the speed of a ship passing through it. Lake St. Clair furnishes an example of a waterway where the restricted dimension is depth, the width being several miles. The logs of two ships, each loaded to within 2 ft. of the bottom of this lake, showed a reduction of speed of 16 to 18%, as compared with the speed of the same ships in the deep water of Lake Huron. While data on this point are not as numerous as might be desired, it was believed to be on the safe side to assume a reduction of 20%, which was adopted in the investigation referred to. New data, collected since the close of the investigation, confirm those used.

If the width of the waterway is also restricted, new retarding conditions result. When the ship moves forward its length, a volume of water equal to its displacement passes between the ship and the bottom and sides of the waterway to maintain the water level, creating a back current. If the speed of the ship through the water remains the same as in wide, shoal water, its speed past a fixed land point will be reduced by the speed of the back current. In the investigation this reduction was made, although the amount appeared to be somewhat excessive, because, in the first place, the proper reduction was already in part provided for by the adopted reduction of 20% for the effect of shoal water, and, in the second place, because the amount of water transferred from the bow of the ship to the stern was calculated as the product of its midship section by its length, without allowing for the reduced sections near the bow and stern. The calculated back flow was therefore too great, and the reduction of the speed of the ship as taken was too great.

To create the back flow and maintain it past the ship requires a head of water which opposes the movement of the ship. This, however, the investigation showed to be unimportant in the wide channel adopted for the waterway and with the speeds to be permitted in it.

These reductions of speed were applied in the case of a ship having a speed of 12½ miles per hour in the deep, open lake, resulting in speeds, with the same expenditure of power, varying from 8.2 miles per hour, in the ordinary section 215 ft. wide at the bottom, to 9.5 miles per hour in a channel 1 000 ft. wide at the bottom.

An investigation of this kind must be supported by experience, to be trustworthy, and therefore the actual movement of ships in other canals was examined with great care.

Manchester Canal.—The bottom width is 120 ft., the depth 26 ft., and the cross-section is about 4 400 sq. ft. in earth sections. In a paper presented to the VIIth International Congress on Navigation, in 1898, the Chief Engineer, Mr. W. H. Hunter, gave the dimensions

of a number of vessels which traversed the canal at speeds varying from 7.3 to 13.6 miles per hour. The slower rate was for a ship 255.3 ft. long, 33.7 ft. beam, drawing 17.6 ft. The largest ships traversing the canal are about 450 ft. long and 50 ft. beam. The writer accompanied one of the ships for several miles and carefully noted its speed. It was loaded to within a few inches of the canal bottom, and therefore steered badly, requiring the aid of tugs, but the speed reached 6 miles per hour. In the consideration of the permissible speed in a waterway, either from a theoretical or practical standpoint, the ratio of the area of the ship's immersed cross-section to that of the water, is a controlling feature. In the case of the ship just mentioned the area of the cross-section of the waterway was 3.7 times the immersed cross-section of the ship. This ratio will be designated r. Mr. Noble.

Suez Canal.—When opened, and for many years afterward, the bottom width of the Suez Canal was 72 ft., and ships were permitted to move at the rate of 6.2 miles per hour. The value of r for the larger ships was probably a little greater than 3. The bottom width of the standard section of the Deep Waterway is almost exactly three times as much, and the cross-section of the largest ships traversing it will probably not be as great. If the comparison be made by means of the ratio r, its value for the largest ships expected in the Deep Waterway will be 5.5, instead of 3, as at Suez. Whether the comparison of these ratios, or of bottom widths, be made, a speed of 8.2 miles per hour in the Deep Waterway will appear to be much safer than one of 6.2 miles in the Suez Canal.

As to the practicable rate of speed and degree of security attainable in an artificial waterway, no better example can be cited than the St. Clair Flats Canal, where serious accidents seldom or never occur. This is believed to be the most crowded waterway in the world. The maximum speed permitted by regulations is 8 miles per hour, but the largest freight steamers frequently pass at a higher rate; the largest passenger ships attain a rate of 11 to 13 miles per hour and a speed of 15.4 miles per hour is of record.

With these examples in view, the speed of 8.2 miles per hour in a straight waterway of 215 ft. bottom width appears moderate. The width is to be increased on all curves of less than 12 000 ft. radius, the widening being 1 ft. for each reduction of 200 ft. in the radius. A reduction of permissible speed, equal in miles per hour to

$$1.5 \times \text{degree of curve},$$

is made in the standard canal section, the reduction being reduced where the bottom width is greater. While this allowance is purely arbitrary, it is believed to be sufficient.

In the Suez, and other very narrow waterways, one of two meeting ships ties up. This is not found necessary in the artificial channels in the Great Lakes system, but the speed of both ships is reduced. In the

Mr. Noble. 300-ft. channels of the St. Mary's River, where the channel banks are submerged, the regulations provide that the speed of both ships shall be reduced to 6 miles from a permitted speed of 9, and, excepting in special localities where the current is very strong, this has been found sufficient. In the somewhat narrower channel of the Deep Waterway the assumed reduction of speed is to about 4 miles per hour. The number of meetings is deduced from an assumed traffic of 25 000 000 registered tons annually carried in ships averaging 2 500 tons net register, or 10 000 ships per year. This discussion thus far relates to channels in earth. Objection may be made that in channels in rock with rough sides such speeds would be dangerous. The reply to this would be that no such channels are contemplated. In rock the bottom width is to be increased and the sides made vertical, by channeling machines where the rock is sound, and by retaining walls where these are necessary.

The delays at locks will not be discussed here in like detail; briefly, the allowance for these delays is based on ample experience at the St. Mary's Falls Canal in the movement of ships and the other operations of locking. In addition to this a considerable period has been allowed arbitrarily for delays at lake points where, after storms, vessels may occasionally arrive more rapidly than they can be passed through the next lock, and for smaller delays at each intermediate lock.

In designing this waterway the view has prevailed that it would not be worth making unless it were adapted to more speedy navigation than the principal foreign canals. A much wider prism and better lock facilities are therefore provided, and it is confidently believed that the estimates of time required for passage through it will stand investigation.

Mr. Haupt. LEWIS M. HAUPT, M. Am. Soc. C. E. (by letter).—These papers open up a broad field for discussion, not only in engineering and economics, but in administration and statecraft.

Mr. Randolph's succinct discussion contains much in little, and is certainly a sagacious compromise, as it makes provision for the progressive expansion of the capacity of the waterway.

Experience has invariably demonstrated the inadequacy of rigid dimensions to keep pace with the growing demands of commerce and the necessity of a flexibility which will adapt itself to the rapid growth of tonnage.

As early as 1847 (before the Sault Canal was seriously thought of) the late J. J. Abert, Hon. M. Am. Soc. C. E., Colonel, U. S. Topographical Engineers, discussed the "Probable Increase" of the Lake trade, in an official report to Mr. Marcy, Secretary of War, in which he said:*

"It is difficult to approach this part of the inquiry without fear of

* Ex. Doc. No. 19. Thirtieth Congress. H. of Rep., First Session, Jan. 12th, 1848.

Mr. Haupt.

appearing to exaggerate. Those who knew these Lakes thirty years ago, and who know them now, will admit that existing facts have baffled human expectations, and that the wildest speculations of the imagination have been more than realized in the vast increase of their commerce. Then, if we examine into the elements of this increase, we can perceive no reason to doubt a less energetic action of these elements, for many years to come, than has been realized in the past."

That this forecast has been fully justified by subsequent events is confirmed by the statements of General O. M. Poe, whose investigations of the tonnage through the Lakes well qualified him to state the facts. He said:

"For thirty-five years I have watched the increase of the Great Lakes commerce, but neither I nor anyone else has been able to expand in ideas at the same rate. The wildest expectations of one year seem absurdly tame by the side of the actual facts of the next."

In view of this experience, it is somewhat surprising to read that so keen a statesman as Henry Clay opposed Hon. John Norvell's motion to construct this canal, in 1840, by the statement that it was "a work beyond the remotest settlement in the United States, if not in the moon."

Henry Clay evidently did not know of the latent resources of the Lake basin, nor the relative economies of water transportation—and even at the present time there is much misunderstanding as to the effect upon our industrial growth due to increased facilities.

It is well known that transportation seeks the line of least resistance (as measured by the total cost from mine to market). Tolls, transfer and terminal charges are as much an element of diversion as are physical obstacles. The Carnegie Company is now making efforts to ship direct from Lake ports *via* the Welland and St. Lawrence Canals, after making the overland portage by rail. Were the Lake Erie and Ohio River Ship Canal opened it would not only greatly facilitate this movement, but it would also augment the coal tonnage to Eastern Atlantic ports, and hence it would seem to be unwise not to make provision in the dimensions of the canal for not less than between 15 000 000 and 20 000 000 cargo-tons soon after its opening to tidewater. There is, no doubt, much truth in the contention of Major Symons, that if the freight once reached Lake Ontario it would not lock up over a high divide and longer route to maintain the City of New York as a commercial terminus, but would be switched off *via* the Montreal route; but, at the same time, that would seem to be no reason for denying to the densely peopled manufacturing and productive agricultural districts tributary to the Lakes the advantages of lower rates and more extensive markets. New York City is not the United States, and if that city may not share in the benefits (which the writer does not admit would happen), other sections should not be debarred from such advantages.

Mr. Haupt. It is said that "if built by the United States, the benefits should all accrue to the United States;" and, again, "its benefits should accrue only to the United States." The only route which permits this is that "along the line of the present Erie Canal," and hence the prism of lesser dimensions, with a barge system of carriers, is urged.

But can the beneficent influences of a canal or cheap water route be restricted to any country? Do not the waterways of France and Germany enable our exports and their imports to permeate every avenue of trade, and supply points not otherwise accessible at the same rates, to the benefit of our producers? If our shortest and cheapest route to our foreign markets lies through Canadian waters, is there any reason why our producers should not utilize them rather than pay for transfers and storage at both ends of a broken and circuitous route?

It should also be noted that the staple products of a State tributary to a deep water route are quoted higher than those at remote points and which require transhipments, so that the producer reaps the benefit of the cheaper route, while the consumer also buys at a lower price because of the economy in cost of carriage.

Money spent in the maintenance of an expensive system requiring, say, 60% of the gross income for operation when one is available which can be maintained and operated for one-half or one-third this cost, is extravagant. It has been estimated by Stevenson that the value of a commercial channel varies as the cube of the depth, while the economy of bulk movements is fully sustained by the rapid increase in the size of ocean freighters and the demand for deeper channels to carry them.

Many minor questions suggest themselves, as speed, ratio of beam dimension to section of canal trunk, number of trips per annum, cost of plant for a given tonnage movement, etc., which have been more or ess fully treated at the Navigation Congresses and by the members of this Society, so that it is not desirable to review them here, as the intention of the writer is merely to emphasize the need of making early provision for the largest movement, in view of the rapid increase of population and traffic in sight.

It does not appear to be appreciated that by the year 1930 our population will have almost doubled, and that we are increasing three times more rapidly than any of the civilized nations of the world whose statistics are available to the writer. Ordinary prudence would therefore demand that early provision be made to maintain our freedom of internal circulation, and the creation of external markets to provide employment for the next generation, and prevent degeneration and distress.

During the past century each decennial ratio has shown an average decrease of $\frac{12}{400}$ of the preceding ratio, yet the actual numerical increase of population has gone on in a geometrical ratio. The

increase during the past decade, for example, was nearly 14 000 000, or more than the entire increase from the discovery of America to 1830, and between 1920 and 1930 the increase should be about 25 000 000 souls. Another factor which will augment greatly the commerce through the enlarged canal will be the opening of the link between Chicago and the Mississippi River, now being urged by the Illinois River Valley Association, thus bringing the waterways of the Great Basin into unison with those of the Lakes during the season of navigation. This is not so remote as was the Sault Canal in 1840, and it is one of the great and urgent improvements required by the present generation, and which will promote the future of our great Republic. Let the American Society of Civil Engineers be found in the forefront of all these great movements to develop our commerce. Mr. Haupt.

RUDOLPH HERING, M. Am. Soc. C. E. (by letter).—The relative merits of a ship canal and a barge canal from Lake Erie to the Hudson River have evidently been insufficiently demonstrated to enable a decision to be reached at present—a strong array of facts and talented arguments still appearing on both sides. Mr. Hering.

One might draw the inference that therefore a fair balance exists between the two projects, and that the total advantages are nearly equal, although not identical. It seems more probable, however, that there is as yet insufficient knowledge regarding some of the facts which must control the enterprise, and that considerable time may yet elapse before they are obtained.

Regarding the cost of construction there should not be much difference of opinion, if a definite plan is once established. The probable revenue, on the other hand, is a speculative sum, and neither the authors nor some of the discussors seem to have supported their assumptions with sufficient evidence to satisfy either the capitalist or the legislator. It seems to the writer that here there is room for more facts.

Leading up to the revenue is the use that will be made of the canal; and this depends partly upon the tolls to be exacted and partly upon the speed which can be obtained.

In the Kaiser Wilhelm Canal, vessels capable of making 16 knots per hour in open sea, with a midship section equal to one-third of the canal, and using the same power, made only between 5 and 6 knots per hour. In the Suez Canal, the *Austral*, with 43 revolutions of the screw, and capable of making a speed of 11 knots in open sea, made only 5 knots per hour. We, therefore, cannot rely on much higher speeds than these for large vessels, even in a ship canal such as the one proposed, which fact, in addition to those mentioned, affects the probable revenue.

The suggestion that steamers from the Upper Lakes would go to Europe *via* the St. Lawrence River, that is, through Canada, instead

Mr. Hering. of *via* New York City, does not seem to the writer to argue against the ship canal, any more than a statement that the Michigan Central Railroad, passing from Buffalo to Chicago through Canada, would injure our national interests. Why should not a United States steamer, as well as a railroad train, pass through Canada? The section from Lake Ontario to New York would have to depend largely on the business intended for the Atlantic Coast. It may not be improbable that even the Gulf Coast could be supplied more economically by such a ship canal from the Lakes, and without transfer, than by the Mississippi Valley or by rail.

One reason, not already suggested, why private capital prefers investments in railroads to long canals, may be the fact that the capital required is very much larger. The investor is not much interested in the other fact, that the running expenses are much larger for railroads than for canals.

Mr. Rafter. GEORGE W. RAFTER, M. Am. Soc. C. E. by (letter).—Mr. Hinds writes approvingly of the continuously-descending canal from Buffalo to the Mohawk Valley, but it seems clear to the writer that, had he possessed more extensive information as to the difficulties of the route, this project would not have received his approval. In the end it will pass into the realm of impractical projects, which have only gained importance so long as the conditions were unknown.

The writer was Consulting Engineer to the Canal Committee appointed by Governor Roosevelt. This Committee began by assuming that a continuously-descending canal was in every way a meritorious project, and hence directed, first of all, that it be examined in detail. It soon appeared that there were two routes, as follows: (1) A southern route, which passed to the south of Seneca River; (2) A northern route, passing to the north of that stream; and finally, a route which was not continuously-descending, *via* Seneca River itself. The southern route is the one suggested by Elnathan Sweet, M. Am. Soc. C. E. On very casual examination it appeared certain that this route involved very great difficulties for the entire distance from Newark (the proposed point of diversion) to near Syracuse, a distance of over 50 miles. The country is sand and gravel, with absolutely no stone, while at Syracuse there is a very heavy cut to be made. The Montezuma marsh is also encountered. Even for a 12-ft. canal the estimate for 58 miles was $29 000 000.

The southern route having turned out to be exceedingly expensive, a route to the north of Seneca River was then examined. The region here is of the same general character as to the south, except that the Montezuma marsh is avoided. There would be a crossing of Seneca River, a short distance east of Baldwinsville, which would require a very deep and heavy foundation for an aqueduct. The estimated cost of this route was $22 000 000 for about 58 miles.

Mr. Rafter.

The high-level, continuously-descending canal, by either the northern or southern routes, having thus developed very great difficulties, the writer then proposed the Seneca River route, which in every particular answers the requirements. Space will not be taken to describe this route in detail. The State Engineer informs the writer that his report thereon will be published in the Annual Report for 1900, which will make it available to anyone interested. Attention, however, may be directed to the maps which accompany the report. They were compiled from the field sheets of the U. S. Geological Survey at a scale of $\frac{1}{48\,000}$, and exhibit, it is believed, every necessary feature.

In addition to these three routes, an extension of the Syracuse level, east and west, was examined. The total distance, carefully gone over, was fully 300 miles. Approximate profiles were plotted for the several routes, and it is believed that there are no longer any unknown problems in the country from Newark to Syracuse, all of which is set forth in the report in considerable detail.

The practical conclusion to be drawn from this examination is that for a canal of the dimensions of the proposed deep waterway, the project, while not absolutely impossible, becomes substantially impractical. There are ways by which the same result may be obtained so much cheaper as to render it exceedingly improbable that a canal will ever be carried out by the continuously-descending route.

The locations of the several canal lines are made in such a manner as to bury the canal below the present surface, as far as possible, thus insuring freedom from embankment breaks. By way of further insurance, embankments over 10 ft. in height have been designed with masonry core walls, in accordance with the best recent practice. Under 10 ft. in height they have been designed merely with puddle walls. In water-tight materials, the puddle walls have been omitted.

Some question may arise as to the necessity for masonry core walls in canal embankments. In the writer's opinion, they are necessary, in such large construction as is here proposed, as an absolute guarantee against breaks. A main line of transportation—a national highway—should not be subject to the possibility of broken embankments, with consequent delay of all traffic for 5 to 15 days.

In order to show the experience under this head on the New York State Canals, Table No. 10 is submitted. This table includes all breaks reported by the Superintendent of Public Works from 1888 to 1898, inclusive, except for the year 1890, for which the data are not at hand.

The most serious break was that at the Adams Basin on the Erie Canal, in 1888, which stopped all navigation between Rochester and Buffalo for 12 days.

In 1891, two breaks on the Erie Canal occurred at the same time—one at an aqueduct and the other a defective embankment—which required 10½ and 9 days, respectively, to repair.

Mr. Rafter.

TABLE No. 10.

Year.	Number of breaks reported.	Total detention, in days.	Percentage of a navigation season of 210 days.
1888	7	24	11.4
1889	4	14	6.5
1891	5	28	13.3
1892	5	7	3.3
1893	4	21	10.0
1894	6	10	4.8
1895	3	12	5.7
1896	2	6	2.9
1897	4	55	26.2
1898	11	74	35.2
Totals for 10 years	51	251	Average 12.0

In 1893, a break of an embankment of the Glens Falls feeder required 11 days to repair.

In 1896, there were two breaks, and the total detention was only 6 days. One of these breaks was on the Black River Canal and the other on the Eastern Division of the Erie Canal.

In 1897, a serious break occurred on the Forestport feeder, which required 38 days for repairs. These figures are included in the total detention for that year.

In 1898, the total number of breaks was eleven, causing a total detention of 74 days, of which 16 are included in the repairs of a break in the Forestport feeder embankment at the same point as the break in 1897. With the exception of two breaks on the Champlain Canal, all the other breaks of 1898 were on the Erie Canal, the total detention from the Erie Canal breaks being 53½ days. The Erie Canal breaks were all through embankments, and, with one exception, were at points where culverts pass under. The detail of the foregoing breaks may be obtained from the Annual Reports of the Superintendent of Public Works.

The statements given in the Superintendent's reports show that muskrats, by their burrowing, frequently cause embankment breaks. So far as known, masonry core walls are the only effectual remedy for this difficulty.

Breaks at and about the ends of locks form also a considerable proportion of the whole. The carrying of a concrete core wall into the embankments at the lower ends of locks would correct this difficulty.

A strong argument for the additional expenditure required to construct core walls in embankments may be drawn from the foregoing tabulation of the number of breaks, etc., from 1888 to 1898, inclusive. Even when cases like the Forestport feeder breaks, in 1897

and 1898, are deducted, the clear indication is that embankments without core walls are too dangerous for a great through transportation line such as is here proposed. Such a line, to be satisfactory to all the interests using it, must be so constructed as to be beyond the mutations of ordinary accidents. It would be difficult to make any time-limit contracts with the possibility of delays of 5 to 20 days caused by breaks. Mr. Rafter.

In considering the foregoing question on its merits it must be further remembered that doubling the quantity of water in the canal prism makes the destructive effect of breaks at least fourfold as great as at present. The cost of repairs and damages would, therefore, become very large.*

Taking the foregoing into account, the writer's view is that new work should include estimates for masonry core walls in all embankments over 10 ft. in height.

R. P. J. TUTEIN-NOLTHENIUS, M. Am. Soc. C. E. (by letter).—The writer agrees with Mr. North that all sea commerce is not carried in ocean leviathans, but that fair profits may be made by smaller vessels. Freighters of the same size as the steamers which run regularly from Cöln and Duisburg, on the Rhine, to different ports on the North Sea, and are said to pay a dividend of 13%, would probably carry freight advantageously from Duluth to New York if a canal of proper dimensions existed between the Lakes and the Hudson. Mr. Tutein-Nolthenius.

As will be seen by Table No. 11, which gives the dimensions of all the marine steamers now running on the Rhine, different companies build ships of different lengths, and each adheres to the dimensions once preferred, which seems to prove that, between certain limits, all types are profitable. For example, the Hamburg Steamship Company in 1885 preferred steamers about 230 ft. in length, and the new vessel built for it in 1899 is of almost the same size, while the Neptune Company (the largest owner of this kind of steamers), prefers vessels of less length, only increasing from 140 ft. in 1890 to 170 ft. in 1898.

When the Rhine is at an extremely low level—which seldom happens—these steamers cannot load to their full draft, and part of their freight is then stowed in barges, which the steamer tows alongside, until approaching the ocean. Then this supplemental cargo is transferred to the steamer, while descending the river, in order to lose no time by stopping. The barges remain in the river.

The great pecuniary advantage of not transferring freight in an intermediate port is proved by the fact that these companies make greater profit by loading their small marine craft at Cöln, and sending them directly, say to Hamburg, than by building large barges, such

* It would be interesting to know the cost of repairs to breaks and the ensuing damages for the last 40 or 50 years, or since the enlargement of 1835-62 was fully completed. Without having the figures at hand the writer has little doubt that, on the average, the cost of such breaks would have paid the interest on the first cost of properly constructed core walls.

TABLE No. 11.

Name of Rhine marine steamer.	Tonnage. Gross.	Tonnage. Net.	Length.	Beam.	Draft, loaded.	Depth to deck.	Year in which the vessel was built.	Number of voyages per year (out and back) = one voyage.	Destination.	Name of Owner.
			Ft.	Ft.	Ft.	Ft.				
Arion	290	170	118	20.6	9.6	11.8	1874	17	From Cöln to Bremen.	Dampfschifffahrt-Gesellschaft "Neptun," at Bremen,
Jason	344	197	140	22.4	10.10	12.5	1890	16	" " Lubeck.	" " " "
Iris	343	201	141	22.2	10.2	12.5	1890	16	" " "	" " " "
Flora	344	196	141	22.4	9.10	12.6	1891	20	" " Bremen.	" " " "
Themis	475	345	160	24	10.10	11.9	1891	13	" " Stettin.	" " " "
Saturn	478	346	159	23.4	10.10	11.9	1891	13	" " "	" " " "
Luna	468	279	160	24	11.2	12.5	1892	13	" " Dantzig.	" " " "
Rhea	492	293	160	24	12.6	13.4	1892	12	" " Köningsbergen.	" " " "
Pax	513	301	160	24	11.10	12.6	1893	16	" " Hamburg.	" " " "
Tortuna	513	304	160	25.3	11.6	11.11	1893	12	" " Dantzig.	" " " "
Stella	479	294	151	23.10	11.2	12.5	1895	13	" " "	" " " "
Thalia	465	286	151	24	11.6	16.1	1896	17	" " Hamburg.	" " " "
Pollux	518	319	165	25.9	11.6	15.1	1896	13	" " Stettin.	" " " "
Castor	519	320	164	24	10.2	16	1896	17	" " Hamburg	" " " "
Venus	626	361	171	26	13.2	16.10	1897	10	" " Köningsbergen.	" " " "
Phädra	619	372	168	27	13.2	16.5	1898	9	" " Riga.	" " " "
Ariadne	620	373	168	27	12.6	16.5	1898	9	" " "	" " " "
Egeria	627	381	171	24.8	11.6	17.1	1898	12	" " Köningsbergen.	" " " "
Ruhrort	389	232	161	24.1	9.6	11.10	1896	14	" " Hamburg.	Dampfschifffahrt-Gesellschaft "Hamburg," at Hamburg.
Düsseldorf	158	42	107	20.10	10.2	11.10	1897	14	" " "	
Köln	400	242	161	24.1	10.2	11.10	1897	14	" " "	
Industrie	839	513	236	27.9	11.6	14.8	1885	30	From Cöln to London, and sometimes from the Baltic to Rotterdam and Duisburg.	Rhein-Seeschifffahrt Gesellschaft at Cöln.
Energie	740	452	236	30.1	11.6	14.5	1887	30		
Rhenania	874	655	207	33.9	12	14.5	1894	12	From Duisburg to different ports of the Baltic.	" " " "
Westfalia	997	603	230	34	12	15.4	1899	12		
Elbing I	455	278	165	27.6	12.4	15	1893	10	From Duisburg to Memel and Elbing.	Elbinger Dampfschiff-Rhederei "F. Schichau" at Elbing.
Elbing II	535	317	180	27.9	12.4	15.2	1895	10		

Mr. Tutein-Nolthenius.

as usually carry the Rhine exports to Rotterdam, where the freight is transferred to ocean steamers. And yet these barges carry freight very economically, some being even 328 ft. long, 40 ft. broad and drawing 9 ft.; while the excellent condition of the Rhine estuary allows ocean steamers of any size to enter the inland port of Rotterdam. Mr. Tutein-Nolthenius.

Canals of sufficient dimensions are not only a boon to the counties they cross, but to the whole country at large, as they put an efficient check on railway tariffs. For this reason the Netherlands railway freight tariffs are not as high as those of Belgium and Prussia, where canals cannot compete as effectually with the iron road. While in Belgium two-thirds, and in Prussia even three-fourths, of the railway earnings are contributed by the freight traffic, in the Netherlands the revenues from freight-carrying do not amount to 50% of the total income of the iron roads.

Although the Dutch canals are efficient, they still leave much freight for the railroads, as shown in Table No. 12.*

Table No. 12 shows that in bulk the railways carry less than the waterways; in value, the first are favored, which is natural, as articles of great value more easily bear the higher railway rates.

In Table No. 13, the imports from Prussia during the same year, 1894, are analyzed, after abstracting that part of the imports which only traverses the Netherlands. It shows clearly that for the products the waterway is often chosen even though a greater number of consumers is reached more directly by rail; for strangers are mistaken in thinking that a Dutchman always lives near a canal; this is only true for parts of some provinces.

TABLE No. 12.

Total of imports and exports, 1894.	Tons of 1 000 kilograms = 2 204 lbs.			
	By rivers and canals.		By road.	
	Sailing vessels.	Steam vessels.	Common roads.	Railroads.
Imports from Prussia.....	3 017 585	156 727	42 662	3 236 217
Exports to Prussia.....	4 440 483	292 777	113 415	944 533
Imports from Belgium.....	1 962 431	135 149	54 597	1 020 076
Exports to Belgium.....	1 619 959	129 421	62 324	1 112 335

* Tables Nos. 12 and 13 are extracted from a study which the writer published in the Dutch *Economist*, of 1896. The chosen year, 1894, offers no peculiarities, but more recent years would probably show an increase in favor of the river transportation, as the total number of vessels entering and clearing at the Prussian frontier increased from 44 469 in 1894 to 46 089 in 1899, while the average size of the ships was almost doubled.

Mr. Tutein-Nolthenius

TABLE No. 13.

Imports from Prussia, for domestic use, 1894.	Tons of 1 000 kilograms = 2 204 lbs.		Value.	
	By river and canal.	By railroad.	By river and canal.	By railroad.
Coal and fuel (wood)	1 425 000	2 255 000	$3 550 000	$5 675 000
Building materials	167 000	32 000	850 000	125 000
Stone for river works (rip-rap)	488 000	.....	175 000	.....
Lumber	38 000	22 000	325 000	175 000
Ore	80 000	17 000	975 000	425 000
Manufactured metal	137 000	163 000	9 325 000	13 175 000
Fabrics	108 000	96 000	8 725 000	7 800 000
Agricultural products	43 000	52 000	3 500 000	2 275 000
Item from the Indies and the Orient	1 000	9 000	50 000	1 350 000
Manure	23 000	32 000	25 000	50 000
Unclassified freight	10 000	4 000	400 000	350 000
Totals	2 520 000	2 682 000	$27 900 000	$31 400 000

In conclusion, although it is evident that a canal from the Hudson to the Lakes will never offer such facilities as the Rhine, the writer is convinced that a canal better adapted to modern needs than the present Erie Canal (which, however, considering the period of original construction, is a masterpiece not equaled in Europe), will be of inestimable value to New York and to the counties it crosses. It will also stimulate the railways to still more economical management, and thus be a profit to everybody.

Mr. Wells.

Lionel B. Wells, M. Inst. C. E. (by letter).—In 1900, the tonnage of the Manchester Ship Canal reached 3 000 000 tons, of which 2 800 000 tons were in sea-going ships. The canal was constructed to accommodate ships of 3 000 to 4 000 tons, but ships of nearly 6 000 tons gross have been built for the express purpose of trading to Manchester, and do so.

The largest ship which has hitherto navigated to Manchester is the S.S. *Samoa*, 6 839 tons gross measurement. Her cargo included 20 000 bales of cotton.

The heaviest tonnage delivered on the quays from one bottom is between 6 000 and 7 000 tons. These large ships make 5 knots an hour in the canal. They are limited to this speed, but smaller ones are permitted to steam at 8 knots, when it is found by observation of the particular vessel that this is not injurious to the canal banks.

The writer has passed through the Suez Canal in a ship 329 ft. by 39 ft., drawing 21 ft. of water and having a gross tonnage of 2 200 tons. This ship, at sea, made 11 knots; in the canal she was driven at full speed and made 8 knots, a loss of 27.2 per cent. The regulation limits speed to 5.33 knots, but it is ignored when out of sight of the official. At 8 knots there was considerable wash, and undoubtedly the banks were injured.

In 1885, the writer made some experiments on canal-boat propulsion in a canal 90 ft. wide on the surface, from 11 to 12 ft. deep, and having a sectional area of about 700 sq. ft. Mr. Wells.

The trial was made with a steam tug 76 ft. long, 12 ft. 8 ins. wide, having a draft amidships of 5 ft. 3 ins., and an immersed amidship-section of 60 sq. ft. The speed on a lake was 10¼ miles, and in the canal 7½ miles, a drop of 26.8 per cent.

Over the same course, a steam launch 79 ft. long, 7 ft. 9 ins. wide, with an immersed amidship-section of 30 sq. ft. was tried, and made 8¼ miles in the lake and 7½ miles in the canal, a drop of 9.09 per cent.

L. E. Cooley, M. Am. Soc. C. E. (by letter).—The following notes are designed to present some data on the relative value of three projects for a waterway from Lake Erie to the Hudson River, in respect to the over-sea trade only, as the conditions may be assumed at some time in the future and after such waterways have had time to develop their logical relation to the commercial movement. Mr. Cooley.

The conditions are:

(1) Unlimited ocean navigation extended to the Lakes by works of the greatest practicable efficiency.
(2) Lake navigation extended to the seaboard.
(3) Barge navigation in barges of a dead freight capacity of 2 500 to 3 000 tons. The project now under consideration by the authorities of the State of New York, for barges of a capacity of 1 000 tons, is regarded as entirely inadequate and as holding out no better promise, under future railway conditions, than the Erie Canal has experienced under past and existing conditions.

The writer is twice on public record—in the report signed by the Advisory and Consulting Engineers to the Committee of Investigation of Expenditures under the "Nine Million Act" in 1898; and again, in 1899, in a letter to the "Roosevelt Committee," headed by General Greene (which letter, however, was mangled in publication).

A policy of progressive change and relocation was advised for the Erie Canal System, on the basis of locks for six canal-boats, or 330 x 36 ft., and an ultimate development for a barge navigation of the capacity herein mentioned.

The writer has a high opinion of the value of barge navigation, and for nearly fifteen years has advocated a barge route from the Lakes to the Gulf, with locks for six barges in one tow, on a depth of 14 ft. This has been the declared policy of the State of Illinois since 1889. Such a fleet would carry 15 000 tons with great economy. He has never considered, however, that the economy could approach that of the single hull of the same aggregate capacity in any trade for which the single hull is adapted.

Mr. Cooley.

1. THREE WATERWAYS.

(*A*) *Ocean.*

Lock, 660 x 72 x 32 ft., for ships of dead freight capacity of 21 000 net tons.

Equated length * of route, Chicago to New York, 1 900 miles, or 1 000 miles from Lake Erie.

First cost, $300 000 000.

Interest, maintenance and operation, 4%, or $12 000 000 per year.

(*B*) *Barge.*

Lock, 330 x 36 x 16 ft., for barges of dead freight capacity of 3 000 net tons.

Equated length * of route, Chicago to New York, 1 600 miles, or 700 miles from Lake Erie.

First cost, $100 000 000.

Interest, maintenance and operation 4%, or $4 000 000 per year.

(Barges capable of carrying 2 500 tons on 14 ft., the depth proposed for the Lakes and Gulf project, with locks for six barges and tow boat; capacity on 10 ft., 1 500 tons. The dimensions are fixed on the basis of six Erie Canal boats.)

(*C*) *Coast and Lakes.*

Lock depth of 21 ft. for boats having dead freight capacity of 6 700 net tons for sea-going model, and 8 000 tons for Lake model.

Equated length * of route, Chicago to New York, 1,800 miles, or 900 miles from Lake Erie.

First cost, $200 000 000.

Interest, operation and maintenance, 4%, or $8 000 000 per year.

2. EQUIVALENT LENGTH.

(Basis—Ocean Navigation.)

Barge.—Cost of carrying 1 mile by barge taken as equivalent to $2\frac{2}{3}$ miles by ocean carrier.

Coast.—One mile equivalent to $1\frac{2}{4}$ miles.

Lake.—One mile equivalent to $1\frac{5}{8}$ miles.

Rail.—One mile equivalent to 10 miles.

Terminal Equivalent.—This is taken as an equivalent to 2 500 miles of ocean carriage. This equivalent measures, in miles of actual carriage, the time in port, port charges, cost of stowing and discharging cargo; in fact, all costs from warehouse or other carrier at origin to warehouse or other carrier at destination, as distinguished from the actual cost *en route*.

* The equated length will vary with the normal speed in free water, the rate allowed in restricted channels, and the lock time, and will vary with the treatment. It involves a large field for good judgment.

Mr. Cooley.

TABLE No. 14.—EQUIVALENT OCEAN CARRIAGE, IN STATUTE MILES— CHICAGO TO LIVERPOOL.

(Ocean, New York to Liverpool, 3 500 + 2 500, or 6 000 statute miles.)

Means of transit.	Equivalent ocean.	Rate per ton.
Ocean (unlimited waterway)	7 900 miles	$1.580
Coast (21-ft. waterways)	11 775 "	2.355
Lake and ocean (one transfer)	11 425 "	2.285
Barge and ocean (one transfer)	13 767 "	2.593
Lake, rail and ocean (two transfers)	16 963 "	3.393

NOTE.—Rate taken at ½ mill per ton-mile for the actual ocean carriage. This corresponds to $1.20 between New York and Liverpool. $1.40 between Buffalo and New York by rail, and $0.79½ between Chicago and Buffalo by Lake, the due proportion of the intermediate charge being included. The basis of comparison is the sixth class of the official classification, this being adopted as the average of all freight for the purposes of apportionment in the Trunk-Line Association. Rates in the sixth class usually run about 20% above the grain rate. The average of Lake freight is considerably lower than sixth class.

(*1*) The barge can carry 1 500 miles rather than reship by ocean-carrier, and 2 600 miles rather than reship by Lake carrier. Therefore, it will do a direct business between all Lake points and all Atlantic Coast points permitted by navigable conditions. The theory of the Lakes and Gulf waterway is that barges can work between Lake points and points in the Gulf of Mexico and Caribbean Sea.

(*2*) Lake boats are not considered more suitable for over-sea work than barges, but, under suitable conditions, they will deliver direct to coast points. The sea-going model will be substituted for direct service to coast points remote from New York.

(*3*) The sea-going coaster can carry 3 033 miles beyond New York in competition with a Lake boat, re-shipping to an ocean carrier at New York. It would, therefore, reach some distance beyond the Nicaragua Canal. Such boats are also adapted to the trade of many minor foreign ports and will do a fraction of the over-sea business.

3. LENGTH OF ROUTE.

(*a*) Export wheat in 1897 was carried a mean distance of 4 400 miles from all Atlantic, Gulf and St. Lawrence ports. The opening of the Nicaragua Canal will increase the mean freight route; 4 400 miles may, therefore, be taken as a conservative measure from New York for all foreign freight movement *via* the proposed canal route; and for this estimate, all freight passing the Nicaragua Canal may be treated as foreign.

(*b*) The mean Lake route on wheat in 1897 was 877 miles, and this may be taken for all freight involving reshipment, for the over-sea trade, by rail or Erie Canal.

(*c*) The barge route will be peculiarly favorable to freight originating at, or destined for, Lake Erie ports which does not now find its

Mr. Cooley. way to water routes on account of their shortness. The mean Lake route for this condition is taken at 700 miles.

(*d*) The mean Lake route for the 21-ft. canal may be taken at 750 miles.

(*e*) The mean Lake route for the ocean carrier may be taken at 800 miles.

4. Over-Sea Movement.

TABLE No. 15.

	Relative.	Actual.
Lake, rail and ocean	*1.00	† 8 000 000
Barge and ocean	1.50	12 000 000
Lake and ocean	1.90	15 200 000
Ocean	3.00	24 000 000

* It is presumed, from the relative freight rate for over-sea trade, that the 21-ft. channel will not produce a large increase over the barge route, as reshipment is involved, except for small port service. The ocean channel is adapted to all craft, and gives Lake ports all the advantages of seaports, with full control over the movement in tributary territory, and will very greatly increase the movement.

† The grain reaching tide-water in the crop season of 1897 (Atlantic, Gulf and St. Lawrence) was 13 600 000 tons, and the Lake movement was 8 100 000 tons. The export (fiscal year, 1898) was 10 300 000 tons. Over 28 000 000 tons, about 70% of the foreign trade, was handled between Portland and Norfolk. The Lake grain in foreign movement was probably 6 000 000 tons. The total foreign movement (over-sea), using the Lakes, is taken at 8 000 000 tons, and is not assumed to increase with the continuance of existing conditions.

5. Value of Service in Over-Sea Movement.

TABLE No. 16.—(Compiled from Sections 3 and 4.)

Carrier.	Equivalent route.	Rate. (4 mill.)	Saving per ton.	Tons moved. Millions.	Gross saving. Millions.	*Deduction 4% cost.	Surplus millions.	Dividend in surplus.
Lake, rail and ocean ..	17 935	$3.587	0.000	8.0	$0.000	0.0	0.0	0.0
Barge and ocean.....	13 133	2.627	0.960	12.0	11.520	4.0	7.520	7.5%
Lake and ocean.....	12 081	2.416	1.171	15.2	17.799	8.0	9.799	4.9%
Ocean.....	8 700	1.740	1.847	24.0	44.328	12.0	32.328	10.8%

* See Section 1 for capital, interest, maintenance and operation.

Note.—The Barge or Lake Canal will make a better showing in the domestic trade with North Atlantic ports. The Lakes and Gulf waterway will do the domestic work between the Lakes and the Gulf and Caribbean.

6. Lake Territory—Unlimited Ocean Navigation.

The proportion of the total for the United States is given for the following items:

TABLE No. 17.

Corn, oats and wheat, production, 1898	74 5%
(Same) shipped out of country	82.9%
Population in 1890	46.1%
Railway mileage, 1898	54.0%
Railway ton-mileage, 1898	55.2%
Freight originating on road, 1898	57.0%
Economic potential (capacity of soil)	42.0%

Mr. Cooley.

The foregoing shows the intimate relation that the Lakes, regarded as arms of the sea, would have to the freight production, and justifies the high assumption for traffic under the conditions of ocean navigation. Neither barge nor Lake navigation can command an area so extensive, draw so large a proportion of the freight, or create so much new traffic.

Explanation.

The assumption of 2 500 miles as the value of the transfer (measured in terms of the carrying rate for ocean navigation) is probably too low, and it certainly is much higher under existing conditions. The necessary cost of a transfer of grain may be taken at $\frac{1}{8}$ cent per bushel, including therein not only the intermediate charge, but that portion of the rate incident to the transfer. There is an average loss or shrinkage of 0.3 of 1% on grain, and more on package freight, especially cooperage. All these may be assumed at 25 cents per net ton for grain. This would represent 30 cents per ton for sixth class, or average for all freight, taking the usual tariff rates between grain and sixth class. This is equivalent to 1 500 miles, and leaves an entirely inadequate equivalent for time in port and port charges.

Lake freights are seemingly low. This is, in part, due to the way the rate is made up, and again, to the very low class of average Lake freight, and also to extraordinary terminal provisions for certain commodities. It is assumed that these special conditions will not obtain to the same extent in a foreign movement, and that any advantages cannot persist indefinitely.

Conclusions.

The foregoing presentation does not assume to be more than illustrative, and the writer will not feel called upon to defend it. The data for a proper and final discussion in these matters has nowhere been assembled and made accessible, nor has any accepted attempt been made to expound first principles. The writer speaks advisedly in this matter, and after many conferences with the master-minds in transportation problems. The relative value of different projects is not now capable of close determination.

The writer does not admit the validity of the dividend or commercial valuation as a measure of public utility in any public enterprise, and especially one that is recognized as out of the corporate field. He has, however, thought it expedient to follow the other parties to this discussion, and avoid an essay on that matter at this time.

The writer concludes that the barge proposition, of the capacity which he has given, is superior to the proposed extension of Lake navigation to the seaboard. He also concludes that ocean navigation extended to the Lakes is vastly more valuable than either, and will return more in proportion to the investment; and that such development will become an economic and political necessity.

Mr. Mayer. JOSEPH MAYER, M. Am. Soc. C. E. (by letter).—The objections to the statements made in the writer's paper refer to the practicable speed and safety of navigation in the proposed channel, the time necessary at terminals, the traffic capacity of the canal, and the amount of traffic to be expected.

As regards the first four, the writer referred to the United States Canal Commission as authority, and mentioned the experience in the St. Clair Flats Canal, which is of the same dimensions as the proposed ship canal and is dammed off from the shallow water at its sides.

In regard to the safety of navigation it has been suggested that the great length of the proposed canal, which has 102 miles of standard section and 102 miles of canalized river of much greater section, may make such a difference that the experience in the St. Clair Flats Canal is not to the point. Some facts taken from a paper* by *Sir* Charles Hartley, M. Inst. C. E., and from the discussion on that paper, are therefore added.

The Suez Canal was originally built with 72 ft. bottom width, and was 26 ft. 3 ins. deep. It was then deepened to 27 ft. 10 ins. at low water, and enlarged to a bottom width of 118 ft. with side slopes of 1 on 2 in some places, and 1 on 2½ in others; and with a berm on which rests the stone revetment near the water line for the protection of the slopes. A further widening may be undertaken in the near future. The stone revetment on one side is not in good condition. It is not intended to be permanent, and has not been built as well as that on the other side.

There are nine sidings 49 ft. wide and 2 460 ft. long, for the purpose of permitting vessels to pass each other. The length of the canal is 100 miles, 27 miles of which are lakes. The most northerly of these lakes and the longest is really a swamp dammed off from the canal. Eight miles of the Great Bitter Lake is deeper than the original canal, and permits free and unrestricted navigation for this distance. The other lakes are of very small extent. They are shallow and contribute little to the facilities of navigation.

Vessels going in the same direction are not permitted to pass one another. In spite of this rule, which makes the speed of all vessels nearly equal to the slowest, the average duration of transit is 17 hours 22 minutes, corresponding to a speed of 5.76 miles per hour. The regulations forbid a speed greater than 10 kilometers, or 6.21 miles, per hour. The slope protection in many places could not withstand a greater speed without harm. There are observing stations at considerable distances apart, where vessels are not allowed to pass before the lapse of the time corresponding to the maximum allowed speed. Mr. Lionel B. Wells, an English engineer who passed through the canal in 1898, in discussing *Sir* Charles Hartley's paper, stated that

* "A Short History of the Engineering Works of the Suez Canal," *Min. Proc.* Inst. C. E., vol. cxii.

the speed limitation is generally disregarded between observing stations, and that a speed of 8 knots an hour is frequently attained for short distances. Mr. Mayer.

The yearly traffic is about 3 600 vessels of 9 000 000 net tons. The tidal current in the southern section attains sometimes a velocity of 2.9 miles per hour.

Here is a canal which carries safely an enormous traffic, which is half the width of the proposed canal between the Lakes and New York, and in which there is a strong current. It has about the same length as the standard section of the latter. It does not appear reasonable, therefore, to doubt that the latter, with practically no current, will furnish a safe channel for a very much larger traffic.

The regulations on the Kaiser Wilhelm Canal between the Baltic and North Seas allow a speed of 9.3 miles (15 kilometers) per hour for vessels of less than 16 ft. 5 ins. draft, and 7½ miles (12 kilometers) per hour for vessels of larger draft. The standard cross-section of this canal is 4 520 sq. ft.

Mr. Fülscher, an engineer on this canal, in discussing *Sir* Charles Hartley's paper, states that vessels having a midship-section of not more than one-sixth of the cross-section of the canal suffer but little reduction of speed therein, as compared with their speed in open water.

The proposed canal between the Lakes and New York has a standard section of about six times the midship-section of the vessels intended to pass through it.

As appears from Mr. W. H. Hunter's discussion, 8 miles an hour is a speed frequently attained on the Manchester Ship Canal. Mr. Elnathan Sweet also substantially confirms the estimate of speed adopted by the writer, and bases his view on experiments made in recent years in Germany and France.

The writer has assumed a speed of 7 miles in the standard section and 9 miles in canalized rivers of much wider section. It is evident, from the facts stated, that speeds of 1 mile more than those assumed would have been more nearly in accord with them.

As regards the time spent at terminals, two cases have to be considered: Vessels loaded with bulk freights, like ore, coal or grain, can be loaded and unloaded by special machinery, which will be provided wherever a large amount of freight of this kind is to be handled. Experience on the Lakes shows that during the whole navigation season the average time spent in harbors is about 3 days per round trip, and the assertion that this time will be 10 days is based, not on theory or experience, but on unreasonable prejudice. Vessels loaded with miscellaneous high-class freight need spend not more than 1 week per round trip at terminals, as is shown by the records of the steamers of the American Line, which are scheduled to make one round trip between New York and Southampton every 3 weeks.

Mr. Mayer. The writer's estimates of cost referred to low-class bulk freights, and not to high-class freights. The difference in cost between the different classes, however, would not be more than on railroads.

Transfer of bulk freights to other vessels becomes superfluous as soon as a ship canal exists, as there is no necessity of adhering to the present expensive mode of transporting bulk freights from the West to Europe, or points on the Atlantic Coast which cannot be reached by canal-boats.

Regarding the capacity of the canal proposed, the estimate of the United States Canal Commission was quoted, and the calculation of the proper tolls was based on this estimate.

The capacity of the canal is governed by that of the locks. Present experience at Sault Ste. Marie, and the prevailing average size of Lake and ocean vessels, indicate for the locks proposed a much smaller capacity than that given. But it is evident that what is wanted is not the present capacity of the locks but that at the time when the amount of freight will have grown to be nearly equal to it. On the Suez Canal the average net tonnage of the passing vessels increased from 1 170 tons, in 1873, to 2 640 tons, in 1898. A large increase in the average size of vessels may be expected during the next 20 years, which would increase the capacity of the locks to the same extent. The present capacity of the Sault Ste. Marie locks, therefore, is no direct measure of what the locks on the proposed canal will be able to do. The following letter, received from Mr. Noble in answer to a request, will remove any doubts on this subject:

"CHICAGO, DECEMBER 1ST, 1900.

"Mr. JOSEPH MAYER,
"No. 1 Broadway, New York, N. Y.

"DEAR MR. MAYER,—The estimates of cost for the Deep Waterway are based on a single system of locks for single lifts and a double system where two or more lifts are combined. It is assumed that the cargo of a fully loaded freight ship is twice its net register, that its east-bound freight will be in full cargoes and its west-bound freight one-fourth as much. This makes the total freight one and one-quarter times the net register.

"The capacity of a single lock is determined by investigation to be 25 150 000 tons of freight in a navigation year; of the Lewiston double flight of six combined lifts, of 40 ft. each, the capacity is 35 801 000 freight tons. If the capacity of the single locks should be reached, by doubling them the capacity could be increased to 35 801 000 without increasing the facilities of systems of two or more lifts.

"In arriving at these amounts the following method was pursued:

"Ships are to be locked singly. The average tonnage, net register, is assumed to be 2 500, corresponding to 3 000 tons of freight for a round trip. This average tonnage is greater by far than the present average on the Lakes, but the ships now building (and for the last five years) for the freight-carrying trade exceed this very much. These large ships are crowding the others out, and by the time the Deep Waterway could be built the small ship will not be an appreciable

factor in the business. This tonnage is less than the present average at Suez, where it is increasing quite rapidly. Mr. Mayer.

"The size of type ship being thus arrived at, the theoretical time of lockage was calculated and the resulting tonnage per year. This was greater than could be handled practically. To obtain a coefficient the records of the St. Mary's Falls Canal were used.

"In 1894 all the business was done by one lock, locking generally two or more ships at once. The delays to ships awaiting lockage were large, reaching what may be considered an economical limit. It was determined what change in time of lockage would have taken place if ships had been locked singly; if the ships had been of the larger size assumed for the Deep Waterway; and if the time for filling and emptying the locks had been changed to conform to the time for the locks of the Deep Waterway. Correcting the tonnage actually passed at the St. Mary's Falls Canal to these changed conditions, we have the tonnage which a single lock of the Deep Waterways would have passed with the same sundry delays and the same idle time as occurred at the St. Mary's Falls Canal in 1894 and also with the same loss of time to shipping while awaiting lockage, which loss of time, as already stated, was considered to establish the economical limit of capacity of the waterway. This tonnage was found to be 0.621 of the theoretical calculated capacity, and was considered the best coefficient available. This coefficient was then applied to the theoretical calculated capacity of each system of lockage.

"While the method may not be wholly satisfactory, I do not know of any better one. At no other ship canal in the world has the lockage capacity been reached.

"The traffic capacity figure you have used is probably the one above given with single locks duplicated. I believe the capacity estimates to be safe, and with the information now existing I do not think anyone can successfully controvert them.

"Very truly yours,

"A. NOBLE."

A considerable difference in the real capacity of the canal, however, will not materially affect the argument for or against it, as there is no reasonable doubt that it will be very profitable as soon as the freight transported through it is equal to its capacity. The cost of increasing the latter is comparatively small.

A more important question is that of the amount of freight to be expected. Major Symons, in his report of 1897, has made an estimate in which he gives the amounts of the different kinds of freight which he expects for a canal 24 ft. deep on the Oswego Route, and the writer was fully aware of the fact when this paper was written, but did not mention the estimate, because no evidence is given in that report to support his mere assertions, and because the writer believes it to be impossible to make a detailed estimate of the probable traffic. If anybody had made an estimate 20 years ago of the probable traffic of the inter-lake channels, he would have either greatly underestimated the traffic, or have been laughed at as visionary. The idea that iron ore in any quantity would be transported to Pittsburg from the Lake Superior Region would have been found to be utterly ridiculous and as indicating the ignorance of the author of it.

Mr. Mayer. We now know, from experience on the Lakes, that a great reduction in the cost of transportation will develop an enormous amount of new business, and that it will deflect from distant and more expensive routes business already existing. The development of new business is a relatively slow process, requiring the establishment of new manufactures along the new route, while the deflection of existing business from other means of transportation will take place much more quickly. It is true that no such transport of heavy cheap goods over great distances takes place on the line of the future canal as exists now on the Lakes, but such transport would not exist along the lake routes if lake freight rates were the same as those by rail. To any careful observer the experience on the Lakes should show two things: First, that the new business developed by the lowering of freight rates is more than half the total. Second, that one cannot estimate in detail the new business which will be developed by a great reduction in cost of transportation.

One can with some approximation estimate the amount of existing transportation which will be transferred from other lines to one very much cheaper, but not the new transportation which will be created. It is evident that the canal proposed will obtain most of the grain and much of the provisions passing from upper lake points to the Atlantic coast and Europe; that it will obtain lumber in large quantities in both directions, besides salt, building stone, cement, brick, coal, iron ore, etc.; but to put definite quantities behind all these items, shows only the habit of their author to make positive statements in regard to subjects which he does not know.

The principal data which permit making an approximate estimate of the freight to be expected are furnished by the amount of freight obtained through the Lake rates, due to the improvement of the interlake channels, and by a comparison of the population and the number and importance of the harbors at the two ends of the lake region with those at the two ends of the proposed canal. Since the visible makes a greater impression on us than the invisible, we are apt to underestimate in such a comparison of an existing waterway with a proposed one the amount of freight which may be expected by the latter. The development of the iron mines in the Lake Superior Region is an accomplished fact, and their product goes at present largely to Pittsburg, therefore the argument is ready at hand that there are no iron mines on the new canal, and that the ore of the western mines does not go East. A considerable part will go East after the canal exists, and other sources of freight, as unknown now as the Lake Superior mines were twenty years ago, will arise as soon as heavy goods can be transported cheaply. The quantity of goods produced, transported and consumed is largely dependent on the size of the population which produces and consumes them, and the cheapness of transporta-

tion. And the possibility of transporting them by water from producer to consumer depends mainly on the existence of the appropriate channels and the number and importance of the harbors available. In comparing, therefore, the relative amount of freight which may be expected to pass through the Detroit River and the canal proposed, it is reasonable to take into consideration the populations and harbors connected by the two waterways. If this is done, and allowance is made for the natural increase of business during the next twenty years, it appears to the writer to be very moderate to estimate the then existing traffic through the proposed canal as equal to its capacity. Another argument against a ship canal on the Oswego Route is to the effect that Canada would build a ship canal to Montreal and deflect business in that direction. The larger part of the Dominion is chiefly interested in such a canal on account of the cheap transport to Europe and the United States which would be created thereby. A ship canal from Lake Ontario to Montreal would not materially cheapen transport to these countries after the American ship canal exists; it would be in a precarious position without control of a ship canal around Niagara Falls; and it would be such a ruinous undertaking for a small and poor country like Canada that it is an insult to our neighbors to think them capable of it. Mr. Mayer.

An estimate of the water supply needed at the summit level has been made by one of the discussors, and an objection against the Oswego Route is based thereon. This discussor asserts that the water supply needed at the summit level for each passing vessel is equal to the lock area multiplied by the sum of the lifts of all the locks.

It is reasonable to provide water supply for the full capacity of the canal. At each end of the summit level is a lock. From the passage of the sill by a vessel entering a lock from above, it takes a certain minimum time for this vessel to go to the lower level, move out, let another vessel pass in, rise up, move out, and the next downgoing vessel to advance to the sill. This period of time is required for one cycle of lock operation, and will pass one vessel down, another up. For a given lock area, it varies somewhat with the litt at the lock. One lock chamber full of water is required per cycle, or a volume equal to the area multiplied by the lift. The shortest time required for one cycle is found by observation of existing locks of similar size and lift. It is easy to estimate the influence of a change in lift on the time required for one cycle. The experience at the locks of Sault Ste. Marie allows, therefore, a very close estimate of this time to be made. From this the number of cycles per 24 hours is obtained, and the quantity of water needed for the two locks at the end of the summit level can easily be estimated. If the amount of leakage per 24 hours in the summit level and the two adjacent locks, and the evaporation per day, is added to the foregoing amount, the water needed at the summit level is known. The latter items are

Mr. Mayer. relatively small if the canal is well built. This is all the water needed at the summit. And if the two adjacent locks have the greatest lift of those on the same side of the summit, the water needed for lockages at the summit is sufficient for all lockages below, provided the level water surfaces between any two succeeding locks, in comparison with the lock chambers, are large enough to permit their filling twice without reducing the depth too much on the level. Any additional water needed, however, may be supplied below the summit level. The problem of water supply is therefore not so serious as it would be if the estimate mentioned were correct. The argument based on this difficulty becomes invalid on account of the gross error in the estimate of the water needed.

It has been suggested that it would probably be better to make the canal somewhat deeper and narrower. The writer's studies of the opinions of experts on the Suez Canal lead him to believe that the same area of cross-section as proposed by the Commission, with a depth of 24 ft., would be more satisfactory. At a depth of 21 ft., this would give a width of 192 ft. instead of 215 ft., and a bottom width of about 177 ft., with slopes of 1 on 2½. The Commission, however, undoubtedly had good reasons for the cross-section selected. The width chosen by it substantially agrees with that proposed by the International Commission which investigated the proper means for increasing the capacity of the Suez Canal. But the depth recommended by that Commission was 9 meters, or 29 ft. 6 ins.

It has been correctly stated in the discussion that most of the ocean traffic is carried on in comparatively small vessels which could easily pass through the proposed canal, and that the large vessels are very few and play a small part in the freight traffic, especially in the coasting trade. It is evident, therefore, that for most of the traffic small vessels are more economical than very large ones. The assertion that vessels capable of passing through the proposed canal could not with economy cross the ocean is not supported by the facts.

Since the locks proposed would only be able to handle the traffic for at most twenty years, additional locks would soon be required which could then be built of a size and depth fit for the demands upon them. The canal could then be deepened should it appear to be desirable.

Another very important question touched by Mr. North, is the advisability of levying tolls. The writer does not deny the advantages which any section of the country would derive should the United States decide to pay a large part of the freight charges in that section only. This is substantially what the proposition of building at the expense of the United States a costly canal, which is to be toll free, amounts to. The prospect of inducing people of other sections of the country to vote for such a scheme, however, is very slender, and,

in order to secure a majority of votes, as proposed by Mr. Thomas Curtis Clarke, it would be necessary to couple it with other schemes beneficial to other parts of the country. The writer believes that the reduction in cost of transportation to be brought about by this canal is so large that the levying of proper tolls will not materially diminish the amount of freight which will pass through it; and it is ungenerous and inexpedient for the section of the country to be benefited to expect other sections, not so fortunately situated, to help in paying the yearly expenses incurred for it. Mr. Mayer.

For the purpose of illustrating from an economic standpoint the objections to a toll-free canal, a simplified example containing the essential features of the problem will be chosen.

There are quarries at a town, "A," where a cubic yard of stone costs $2; in another town, "B," are quarries where a cubic yard of equally good stone costs $3; the cost of transportation between the two places is $1.50 per yard. In this case each place uses its own quarries. The State intervenes and assumes two-thirds of the cost of transportation.

Then the town "B" will obtain stone from "A" at $2.50 per yard. The actual cost of this stone is $3.50 per yard, of which the State pays $1. The effect of the interference of the State is that more labor is spent for the stone used at the town "B" than before.

Stone has become actually dearer though it is nominally cheaper. Other effects will be produced, among them, losses to the quarry owners of the town "B" and gains to those of the town "A"; generally the latter effects alone are dwelt upon by advocates of such State interference. When the State omits to charge a reasonable toll for the use of a canal which it builds it not only enriches one section of the country at the expense of the rest, but it increases the production of things at a distance which could really be produced cheaper at home; it thereby increases the amount of labor which has to be expended for obtaining a given amount of goods. There are cases, however, and the Manchester Ship Canal seems to be one of them, where the principal benefit obtained by a canal is the lowering of excessive monopolistic freight rates on competing railroads, and where the attempt to levy tolls covering the yearly expenses of such canals would be destructive of their usefulness. The writer believes that a toll-free barge canal of large capacity, from the Lakes to New York, would have this effect. And the advocates of a barge canal wisely refuse to recommend tolls, as they would destroy most of its usefulness. A barge canal of small capacity, however, would not answer this purpose, as the railroads would find it to their advantage to let it have all the business it could carry, and ignore its freight rates.

The rail freight rates in this country, however, are only about one-third of those in England; the possible reduction is small, and the effect of a competing canal, therefore, very limited.

Mr. Mayer. The tolls proposed for the ship canal by the writer, however, are much smaller than the expenses incurred for transfer on a barge canal; the former is therefore superior, as it pays its way and offers larger benefits to the public.

The writer's criticisms of the barge canal project were mainly directed against the arguments of the New York State Canal Commission, which attempts to prove that a barge canal is desirable, independent of the incidental advantages of lower railroad freight rates due to it.

Theoretically, it would be best, in canals which are not used to their full capacity, to increase the amount of freight using the canals by varying the tolls for the different kinds of merchandise, taking into account origin and destination, in proportion to the value of the service rendered by the canal, charging on no part of the freight more than the traffic will bear. For a canal which is used to its full capacity a uniform toll is the best in every respect. The value of the service rendered by the proposed canal is greatest for freight which saves transfers. The principle of charging in proportion to the number of transfers saved seems to be, therefore, the nearest practicable approach to an ideally perfect system of tolls.

The tolls proposed by the writer were calculated for an annual expense of $9 000 000, allowing for 3% interest. If the United States can obtain the money for construction at 2% interest, the annual expense will be only $7 000 000, and the tolls given would be sufficient, even if the estimate of traffic is considerably in excess of the facts.

Mr. Thomas Curtis Clarke's remarks are interesting, and the writer thinks that the scheme recommended by him for consideration is worthy of careful investigation, which is likely to show that it is not only feasible but economically desirable, weighing the advantages to be gained with the cost of their attainment. If the scheme were as well known in all its aspects, and if its economic merits were equal to those of the canal here considered, the writer would think it advisable to combine the two; but, for the present, he would prefer that those most interested in the eastern canal would come forward, frankly declaring their willingness to pay for the yearly cost by proper tolls, and advocating the passage of a law in Congress providing for its construction on these terms.

It has been asserted that Lake vessels would be very uneconomical on the ocean. The writer does not believe that the equivalents, on the size of which the whole argument depends, have inherent probability, in the face of the actual transportation charges on the Lakes and ocean. All the difference in these is explainable partly by the present small depth of lake channels, and partly by the smaller distances on the Lakes. If a canal of either 21 or 24 ft. depth existed, vessels would be built adapted to both Lake and ocean traffic, and

their disadvantages for either would be small in comparison with the savings accomplished by the avoidance of transfers. Mr. Mayer.

The superiority of a canal 30 ft. deep can only be shown by assuming an enormous traffic. Though the writer believes that such a traffic will exist on this route in the near future, he does not think that after this discussion it is possible to convince a sufficient number of people to induce action by Congress in favor of such a canal. The smaller canal will be more profitable at the beginning, and for this purpose does not require an amount of traffic which appears improbable to the majority of judges.

The capacity proposed by the United States Canal Commission for the beginning is, as appears from Mr. Alfred Noble's letter, 25 000 000 tons, which can be increased to 36 000 000 tons by doubling the single locks. If one of the two rows of locks, in the places where there are several locks in a chain, were made 30 ft. deep, the canal could be easily increased to 30 ft. depth whenever the traffic required an increase of capacity beyond the 25 000 000 tons. This ought to unite all the advocates of a ship canal, because it will fulfill the wishes of those in favor of a 30-ft. canal as soon as the growth of traffic shows this to be advantageous.

The purpose of this paper was to make it evident by the discussion which it would call forth, that the preponderant judgment of those who have studied this question is in favor of a ship canal. Mr. Wisner's paper and the writer's have accomplished this purpose. The objections which have been raised against a ship canal have been effectively answered in the discussion, by those most competent to do so; and many who were either ignorant of, or indifferent to, the subject, have been convinced or made more enthusiastic in favor of an enterprise which is the most important engineering work of the near future.

GEORGE Y. WISNER, M. Am. Soc. C. E. (by letter.)—It is gratifying to note the advance which has been made in general knowledge on the waterway problem since the discussion in the *Transactions* of the Society for June, 1898.* Mr. Wisner.

The present papers attack the problem from entirely different standpoints and by different methods, and arrive at practically the same results; while the discussions, which have been contributed by some of the ablest waterway engineers in the world, although not in harmony as to the actual dimensions which should be adopted, in no way controvert the facts on which the conclusions in the papers were based.

One of the principal issues raised in the writer's paper was that estimates of transportation rates by different routes should in each case include all items relative to the cost of construction, maintenance

* *Transactions*, Am. Soc. C. E., Vol. xxxix, page 273; "The Economic Depth for Canals of Large Traffic," by Joseph Mayer, M. Am. Soc. C. E.

Mr. Wisner. of route, and the cost of moving the expected commerce between terminals, which in any way affect the fixed charges properly chargeable to the rates of the respective routes.

Major Symons calls attention to the writer being a strong advocate of ship canals; yet, in all of his own estimates for transportation rates on his proposed barge canal, he assumes the waterway to be constructed and maintained at public expense, and then attempts to show the great saving in transportation rates, as compared with those on the routes where all fixed charges for construction and maintenance must be taken care of in the transportation rates.

The writer has endeavored to treat each route in exactly the same manner, and wherever fluctuating values have been used, the conclusions drawn are based on results from which the errors from such sources are practically eliminated; and if such methods may be termed those of an advocate, then those adopted by Major Symons need qualifying with a much stronger phrase.

It is immaterial whether the routes be constructed and maintained at public expense, or whether the fixed charges be made a part of the transport rate; the result to the producers of the country is the same. If the route is worthy of being constructed at public expense, it is fair to presume that the people of the whole country are to be benefited, and whatever saving may accrue in transportation rates from Government construction indirectly becomes a tax on the producers who use the line.

If, therefore, when all direct and indirect benefits are considered, a route cannot be shown capable of furnishing better rates with fixed charges included than its competitors, we must conclude that it is not worthy of construction.

In discussing the relative merits of these different proposed waterway routes, there are several important considerations which must not be lost sight of, if a correct and satisfactory solution of the problem is expected.

Existing knowledge as to the natural physical conditions of the routes, and the economical type of freight carrier which can be best utilized on the respective waterways in the transport of domestic and foreign commerce, must be fully considered, and all conclusions based on sentiment eliminated. While most of us would take great pride in such a grand achievement as that of extending the ocean waterways to the ports of the Great Lakes, we must inevitably answer the question, "Will it pay?" before asking the producers of the country to contribute their earnings for its construction. Not that the reduction in transportation rates must be such as to warrant a private company taking up the project for profit, but that the result to the whole country from direct reduction of rates and from resulting development of new commerce and industries will show a balance on the right side.

Mr. Wisner.

Under the most favorable conditions to be expected, it will be at least ten years before either of the proposed waterway routes can be opened for business. The relative movement of domestic and foreign commerce which will exist after that period is the important factor on which both the type of waterway and of freight carrier must be based. At the present time about one-fourth of the wheat raised in the United States is exported; but from the increase in population which may safely be predicted, the present surplus of wheat raised will be required for domestic consumption within less than twenty years, and unless the annual yield can be increased, the export of grain must be eliminated from the calculation. Whatever the future may have in store for the grain business of the country, it is safe to say that the export of raw materials will greatly decrease, and the export of manufactured products largely increase in the near future, which implies a decreasing tonnage for the corresponding value of the commerce.

The Commissioner of Navigation gives the weight of exports from the United States in 1899 as follows:

TABLE No. 18.—WEIGHT OF EXPORTS IN 1899.

	Value.	Weight.	Value per ton.
		Tons of 2 240 lbs.	
Articles, in terms of weight.....	$904 827 281	25 569 729	$35
Articles estimated by experts.....	85 370 277	602 482	142
Lumber, boards and shingles.....	20 138 053	2 142 424	9
Miscellaneous manufactures.....	193 595 611	967 978	200
Total	$1 203 931 222	29 282 613	$41

It will be noted from Table No. 18 that the entire exports in 1899 only amounted to 29 282 613 gross tons, of which 25 569 729 tons, worth $35 per ton, were products, the export of which is likely to greatly decrease in the near future, and that 967 978 tons, worth $200 per ton, were manufactured products, the exports of which are increasing rapidly, and will be likely to comprise the principal part of our foreign commerce during the era for which the the waterway must be constructed. It therefore appears that the waterway, if constructed at all, should be more for the purpose of distribution of products for domestic consumption than for the accommodation of foreign commerce.

The economical dimensions for a waterway, and for the freight carriers which use it, are functions of the distance between freight terminals.

In ocean traffic, with from 3 000 to 5 000 miles between terminals, there is no question that larger ships will be economical, and will be built as fast as the improvement of the depth of terminal harbors will

Mr. Wisner. permit; but, on the Great Lakes, where the length of haul is limited to 1 000 miles or less, the limit in size of economical ship construction has already been reached, and with unlimited depth in the connecting channels of our lake waterways it will not pay to construct freight carriers for lake service alone any larger than those recently put in the service. This statement may seem somewhat strong, but the facts are that with a haul of less than 1 000 miles, the running expenses and fixed charges for ships over 480 ft. long, 52 ft. wide and 19 ft. draft, increase more rapidly than the profits from increase of carrying capacity.

Table No. 19, giving the dimensions, horse-power, speed, cost of ship, running expenses and cost of transport per ton-mile for different types of carriers, is based on actual lake practice and experience, and has been prepared from data furnished by Mr. Frank E. Kirby, who is doubtless the best authority in the world on this class of ship construction.

TABLE No. 19.

Dimensions and draft of ship, in feet.	Number of propellers.	Horse-power.	Speed per hour, in miles.	Carrying capacity, in net tons.	Pay roll and subsistence, per day.	Fuel, oil and waste, per day.	Cost of ship.	Cost of transport per ton-mile, in mills.
480 × 52 × 19...	Single	2 200	12.5	8 600	$60	$117	$387 000	0.128
480 × 52 × 23...	"	2 480	12.5	9 600	60	129	462 000	0.129
480 × 52 × 27...	"	2 800	12.5	11 760	62	143	554 400	0.121
500 × 54 × 27...	"	2 930	12.5	12 600	62	149	612 400	0.120
520 × 56 × 27...	Two	3 100	12.5	13 300	80	155	705 600	0.129
540 × 58 × 27...	"	3 200	12.5	13 980	80	159	771 400	0.130
550 × 60 × 27...	"	3 330	12.5	14 100	82	165	828 400	0.136
480 × 52 × 19...	Single	3 650	15.0	7 650	72	154	410 000	0.141
500 × 54 × 27...	"	4 850	15.0	10 000	76	204	661 200	0.151

It will be noted that for speeds of over 12.5 statute miles per hour the rate increases. If the lines of the vessel be adapted for obtaining greater speed with less power, the carrying capacity is decreased and the cost of carrying correspondingly increased. In computing the cost of transport per ton-mile the prices for labor and materials used are the same for each type of vessel, and, therefore, any variation which may arise from fluctuation of prices will be practically eliminated in the relative cost of transport for different types of ships.

The rate per ton-mile in Table No. 19 only includes those items which enter into the cost of carrying a ton one mile in the open lake. If we take into consideration the greater loss of time by the larger ships at terminals, the difference in cost of transport becomes still less, as shown by Table No. 20, which is a computation of transport rate for the first and fourth of the steamships given in Table No. 19.

TABLE No. 20.—TRANSPORT RATE PER TON. Mr. Wisner.

Dimensions of ship, and draft	480 × 52 × 19 ft.	500 × 54 × 27 ft.
Sailing time of round trip	7 days.	7 days.
Detention at terminals	3 days.	4 days.
Wages and subsistence	$600	$682
Fuel, oil and waste	909	1 183
Insurance on ship	477	830
Insurance on cargo	860	1 260
Miscellaneous expenses	30	40
Interest on investment	530	922
Deterioration, etc	530	922
Profit to shipowner	400	600
Total	$4 336	$6 439
Rate per ton	0.378	0.383

It will be noted from Tables Nos. 19 and 20 that the actual cost of moving a ton of freight 1 mile in the open lake is such a small percentage of the transport rate which must be charged to transact the business, that the length of haul and the amount of detentions at terminals are the important factors necessary for determining the economical dimensions for freight carriers, and, consequently, of the water routes to be used by them.

The rate computed in Table No. 20 is for ships adapted for both lake and ocean traffic, and used for lake traffic only. If freight be carried between Lake ports and New York in vessels adapted for only lake and waterway business, the actual savings on the Lakes by using the deeper-draft vessels would be less than one-half of the estimated fixed charges arising from the excess of cost of construction and maintenance of deeper channels, as stated in the writer's paper.

Since at least three-fourths of the freight carried on the Lakes is for domestic consumption, and because domestic traffic must increase much more rapidly than that with foreign ports, it seems evident that if any waterway be constructed it should be the one best adapted for the distribution of products and manufactures for domestic use.

It is generally conceded that to produce the best results, a waterway from the Lakes to the Atlantic should have dimensions which will permit the passage, at economical speeds, of ships best adapted for the traffic of the water routes connected.

It is also established from the cost of vessel construction on the Lakes, and the cost of transport in carriers of different speeds and dimensions, that the maximum size of steamer for economical transportation for hauls of less than 1 000 miles has been reached in lake practice; from which it appears that the only legitimate reason for constructing waterways more than 21 ft. deep will be solely to accom-

Mr. Wisner. modate foreign commerce between lake and foreign ports. The only saving to be obtained by the use of deeper waterways will be the cost of transfer at New York of products destined for foreign ports, and, since all traffic for the Atlantic coast trade would have to be transferred at New York, if carried in the larger ships, it is probable that the 19-ft. carrier would be more economical on the average, no matter how large the volume of commerce be assumed.

Without regard to the pleasing sentiments awakened by the proposition to open up a waterway from the Great Lakes to the seaboard, capable of accommodating the largest ocean freight carriers, the cold facts must be faced that the interests of the producers of the country are but the collective benefits to be derived by individuals, and unless it can be shown that the benefits to be secured from the construction of a new route, with all expenses included, will exceed those obtained from routes now in use, it will certainly never be built, no matter whether it be a $60 000 000 barge canal or a $300 000 000 waterway for ocean steamships.

Major Symons' statements that "Mr. Wisner has certainly jumped at a conclusion which is in no manner justified by the facts and present data," and that "his premises are entirely in error," seem peculiar, to say the least, when it is considered that he was well aware when he wrote his discussion that the St. Lawrence Canals were actually open for business for the entire navigation season of 1900.

It is technically true, as he states, that the Canadian Canals have not yet been entirely completed. Neither has the St. Mary's River improvement been fully completed, yet its commerce in 1900 was over 25 000 000 tons, while on the new St. Lawrence Canal only one fully loaded freighter is reported as having passed through. Why? Simply because, as stated in the paper, any waterway requiring transfers will fail to divert freight from the lake and railroad lines.

It is a notable fact that the steamers now being constructed for lake and ocean commerce through the Canadian Canals are for 20 ft. draft, it being considered more economical by the builders to lighter through the canals than to undertake transportation on the Lakes with ships of only 14 ft. draft.

The fact mentioned that "the Canadian Government and private parties have only just commenced work at Port Colborne and Montreal to prepare for the traffic which they expect to go through that commercial highway," is one for which the Canadian officials would like to have some legitimate reason. From the tenor of recent articles in Montreal papers, they evidently fear that the desired improvements may never materialize. It must also be borne in mind that the volume of freight for domestic consumption is so large that it practically controls the route followed by foreign trade in the same commodities, and must to a great extent prove a strong handicap for the Canadian route.

Mr. Wisner.

The writer did not state that the Canadian canals were failures, as implied in Major Symons' discussion, but that they had thus far failed to divert traffic from established routes, and that any waterway of less depth than required for the passage of the best type of lake freighters cannot materially modify the transportation rates over existing routes.

Major Symons' comparison, of the effect of the enlargement of the Erie Canal, to the economy of an 8 000-ton steamer over one of 2 000 tons capacity, is not apropos.

The conditions which have caused the decline of traffic on the Erie Canal since 1880 cannot be eliminated by the construction of a waterway only 12 ft. deep, while the economy in the use of larger freight carriers on the Lakes depends simply upon the ratio of the running expenses and fixed charges, due to cost of ship, to the carrying capacity for steamers of different dimensions.

While not prepared to stand sponsor for the exact ratio of power required, respectively, for towing wooden and steel barges, the writer is surprised that an engineer of Major Symons' high standing should for one moment question the fact that the resistance of wooden surfaces to movement through water is largely in excess of that of steel, especially in the case of barges in canals and shallow rivers, where the bottoms cannot be maintained long in good condition except by constant repairs. The fact that wooden ships, with bottoms in the condition similar to that of barges in use on shallow streams, offer great resistance to movement through the water, is so well known that comment is unnecessary. If further evidence is needed to convince Major Symons of his error, a careful study of the resistance of wooden and steel conduits to the flow of water should certainly be sufficient.

If, as stated in the discussion, "one of the strongest arguments in favor of a barge canal following the general route of the Erie Canal, is that business upon it can be done in cheap, light, wooden boats," the project is certainly based upon a very weak foundation, for it is generally admitted that in vessel construction wood must give way to steel long before either of the proposed waterways can be constructed.

While it is true that the insurance rate on the present small canal boats is much less than that used in the estimates given in the paper, it should be noted that the risk on 1 000-ton barges in fleets of five or more, in a 12-ft. waterway and through the lakes and rivers traversed by the route, will be practically the same as that for a steamer having a tonnage equivalent to that of the fleet.

On page 80 of Major Symons' report on a ship canal from the Great Lakes to the navigible waters of the Hudson River, it is stated that:

"The ordinary rates of insurance on the Lakes are 3 to 3½% on steel vessels. No insurance man interviewed thinks that the rates would be less for vessels navigating the canal, while many announced that they would be higher."

Mr. Wisner.

It is not safe to estimate for lake and river insurance at less than 4½%, but, admitting that this rate is too high, the discrimination is really in favor of the canal barge, for the reason that the cost of vessels per ton of carrying capacity is much greater for steamships than for barges, and, therefore, if a less rate be introduced in Tables Nos. 3 and 4 of the paper, the showing for the barge canal would be made even worse than stated.

Major Symons is in error when he states that the cargo insurance used in Table No. 3 of the paper is increased in some unexplainable manner, for the reason that exactly the same rate is used as in his report, but the amount is computed for the cargo carried in both directions, instead of making the shipper pay the insurance on the west-bound freight, as was done in the barge canal estimates. If forcing the shipper to pay all items which make estimated transportation rates undesirably large is a correct and fair procedure, the principle should be still further extended and make transportation practically free. Major Symons has apparently made use of this method, so far as the cost and maintenance of barge route and west-bound insurances are concerned, and it would be interesting to know why the same principle should not be applied in the estimates of railroad rates, by omitting all fixed charges for right of way, construction and maintenance of road.

In view of the large experience that Major Symons has had in connection with lake waterway and harbor improvements, it is surprising that he should not be aware that the barges he describes in his reports would be neither safe nor economical for lake transportation as compared with the large freighters now used in the lake service. If such was the case, we certainly ought to expect a much more crowded state of affairs in the Canadian canals than has ever existed.

In Major Symons' reports and discussion great importance is given the fact that "nearly all of the foreign-bound commerce of New York leaves the port as berth cargoes in the large ocean liners," and that anything like quick dispatch at the port of New York would require a complete upheaval and reversal of the methods of doing business in that great port.

To those interested in rapid and economical methods of transportation, this state of affairs is a strong argument in favor of adopting some other method of interior transportation, which will not perpetuate a system which, from excessive terminal detentions, great cost of transfer, and from diversion of traffic to less economical routes, adds materially to the cost of marketing the products of the country. The very fact that the differential rates on railroads to the seaboard all discriminate against New York is proof that New York harbor is the most economical natural outlet for exports, and, instead of perpetuating existing conditions, the efforts should be to increase the receipts of

freight, so that full cargoes can be furnished to ocean freighters. The commerce of New York is taken as berth cargoes for the simple reason that the volume received for export is not what the commanding position of the harbor and its unsurpassed natural conditions for interior communications entitle it to. Mr. Wisner.

With direct deep-water connection with the great producing centers of the Northwest, the railroads would have to discontinue differentials detrimental to the Port of New York, or lose much of their present traffic.

In either event, the export commerce of the port would increase and make it possible to establish methods which would give better dispatch than at present.

The statement that "the data furnished by Mr. Wisner are not at all sufficient to prove that the Great Lake freighters could with safety make a speed of 8 miles per hour in the canal proposed by the Board of Engineers on Deep Waterways" needs some substantiation before being accepted. What better proof is needed than that large freighters do make such speeds safely in similar canals every day?

The St. Clair Flats Canal is by no means the only restricted section of the Lake waterways, yet it is a notable fact that no accidents have occurred in these channels, except at sharp curves in strong currents, a condition which has been entirely eliminated in the plans proposed by the Deep Waterway Board.

Mr. Hunter's unqualified endorsement of the writer's estimate, that 8 miles per hour as an average speed would be certainly safe, should settle the question beyond all doubt.

The cross-section of the Manchester Canal is only four-fifths of that of the proposed waterway, yet experience has proved that speeds of 8 miles per hour are safe, and licenses permitting such speeds are now issued.

It is true that strenuous efforts are being made to have some of the narrow channels of the Lake waterways widened to 600 ft., where there are sharp curves and strong currents, but in the plans for the proposed deep waterway to the seaboard, sharp curves are eliminated and wide channels provided in rivers wherever strong currents exist.

In view of the facts that the speed of large freight carriers on canals of similar dimensions to those of the proposed deep waterway has been thoroughly established by actual safe practice, and that the time required at terminals has been fixed by experience extending over many years, the closing statement of Major Symons' discussion, that the estimates of Mr. Mayer and Mr. Wisner are theoretical possibilities, while those for his barge canal are reasonable probabilities, must be regarded as a strong exhibition of over-confidence in his own personal views.

The methods and rapidity of handling cargoes at terminals have

Mr. Wisner. changed but little in the past ten years, as shown by Table No. 21, which gives the types of large carriers built in 1890 and 1900, and the average time of detentions at terminals for those years.

TABLE No. 21.

Name of ship	*Matoa.*	*Gates.*
When built, and years compared	1890	1900
Length over all, in feet	290	500
Beam, in feet	40	52
Depth, in feet	21	30
Registered tonnage (gross)	2 311	5 085
Draft of water in channels, in feet	15.5	17.8
Average cargo, in gross tons	2 500	7 000
Average time at terminals per round trip, in hours	51	63

Mr. Mayer has covered the relative merits of government and private ownership of the proposed waterway so thoroughly that but little comment is necessary. His idea that a moderate toll might be allowed, to cover all expenses incurred by the nation, would be a serious mistake if put into practice, for the reason that the benefits derived from such a waterway will be as much of an indirect nature in building up new commerce as of direct value in decreasing the cost of transport, and, therefore, to obtain the maximum benefit, it should be made absolutely free to all.

Mr. Schenck is in error in supposing that loss of time from meeting vessels, and from reduction of speed on curves, has not been provided for in the estimates of time of round trips on the proposed 21-ft. waterway from the Lakes to the Atlantic. It is established beyond doubt that a speed of 8 miles per hour is absolutely safe on tangents, and in passing vessels a reduction to one-half speed has been used in the estimates, and for curves a reduction depending upon the degree of curvature, as stated by Mr. Noble.

Mr. North, in his able discussion, refers to "the determination to make 24 ft. the governing depth for the channels of the Great Lakes," as an argument against limiting the depth of the proposed waterway to 21 ft.

If it were a fact that the governing depth of the lake channels was to be fixed at 24 ft. or more, the writer would be fully in accord with Mr. North's views. No project for channels of over 21 ft. depth has ever been seriously contemplated, and, besides, it has been so thoroughly demonstrated that larger ships than those recently constructed will not be economical in the Lake service, that the shipping associations will probably ask the Government to fix the ultimate navigable depth of Lake waterways at 21 ft.

It is true that in contracts for the improvement of Lake waterways

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the payment for depths up to 23 ft. is sometimes provided for, but this simply arises from the fact that with some kinds of materials to be excavated, a clear navigable channel 21 ft. deep cannot be made without making occasional cuttings from 1 to 2 ft. deeper than required for navigation. Mr. North quotes the writer as authority for the statement that 40 000 000 tons of freight passed through the Detroit River in 1899. This is not correct. The actual volume carried on the entire chain of lakes was not far from 40 000 000 tons, as stated in the paper, while that passing through the Detroit River probably did not exceed 30 000 000 tons.

Table No. 22 shows the movement on the Lakes for the four leading commodities in 1898:

TABLE No. 22.

Commodity.	Total traffic, in net tons.	Eastward traffic, in net tons.
Grain (including flour).....	9 661 411	9 661 411*
Iron ores.....	13 650 788	11 028 321
Lumber.....	4 540 000	2 531 180
Coal.....	8 722 667	.....
Total.....	36 574 866	23 220 912

The report of the Committee on Canals of New York State gives the total entrances and clearances of registered tonnage at Lake ports in 1898 as 124 046 366 tons. Dividing this by two, the Committee obtains the total lake traffic as 62 023 000 tons.

This, however, is misleading, as to the actual volume of freight movement, which, in fact, was only about two-thirds of the volume indicated by the entrances and clearances at the Lake ports.

The entrances and clearances include those of all pleasure and passenger steamers entering and leaving the ports, which at many of the harbors is an important part of the tonnage. To assume, therefore, that the freight movement through the Detroit River will within a few years amount to 80 000 000 tons is wholly unwarranted by the present conditions or future probabilities.

It is true that the commerce of the St. Mary's River has approximately doubled every six years since 1882, but on the Detroit River the traffic has not doubled in the last twenty years,† instead of in the last six years, as quoted by Mr. North, and it must be remembered that this ratio cannot continue indefinitely, and, in fact, that the condition of the Lake grain and ore trade has already reached the stage where the annual increase of volume of traffic must be much less than heretofore. The unprecedented growth of commerce on the Great Lakes

* Including Canadian traffic through Georgian Bay and the Welland Canal.

† See Tunell's "Statistics of Lake Commerce," page 3.

Mr. Wisner. has been due to the development of cheaper transportation by the improvement of waterways, and the consequent bringing into existence of new manufacturing enterprises which otherwise could never have been started. While the free improvement of these waterways has often been criticised as undue favoritism of the competitors of the railroads, it is nevertheless true that the great prosperity of the railroad lines which parallel the water routes has been largely the indirect result of the new traffic which would never have existed had not cheaper transport been developed by waterway improvements.

The effect of waterway improvements on the movement of the Lake commerce is well illustrated by the relative volume of flour carried by vessels and on railroads during the period of channel improvements.

In 1866, the railroads carried approximately one-half of the flour between the upper Lake ports and the seaboard; in 1867, three-fourths; in 1877, 94%; and in 1881, 96 per cent.

The improvement of the St. Clair Flats Canal and the completion of the 15-ft. lock and canal at Sault Ste. Marie in 1881, turned the advantage again in favor of lake transportation, so that, in 1882, the Lake shipments of flour were 21%; in 1886, 38%; and in 1889, 48% of the total volume. It is hardly to be expected that this ratio will materially change in the future, for the reason that winter shipments by railroad are certain to continue, and that future reduction in water rates must be small after the completion of the 21-ft. waterway project, which depth, economical transportation, so far as Lake traffic is concerned, will not warrant increasing.

If a commerce of 80 000 000 tons annually through the Detroit River, with a corresponding increase of traffic to the seaboard, can be guaranteed after the completion of a 30-ft. waterway, the writer will heartily concur with Mr. North as to the desirability of such construction. Not that the cost of transport will be less for Lake traffic than with a 21-ft. waterway, but that the indirect benefits from developing a commerce of 80 000 000 tons will more than repay the additional cost of a larger waterway. Such a result cannot be reasonably expected, and it is probable that 20 000 000 tons between the Lake ports and the seaboard is a much safer prediction; for, with the route closed one-third of the year, the railroads would certainly continue to carry a large part of the commerce.

The total traffic on the New York canals in 1898 was 3 360 063 tons, of which 1 573 227 tons were through freight. The total freight traffic over the New York Central Railroad was 23 403 439 tons, of which only 4 153 084 tons were through freight. The total freight tonnage on the New York State canals and railroads was 67 141 146 tons, of which probably about 15 000 000 tons were through commerce between the freight centers of the country tributary to the Lakes and the seaboard.

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With a deep waterway completed and ready for business, it is probable that the railroads would still carry at least one-third of the through freight, leaving 10 000 000 tons available for waterway traffic.

It will not be safe to estimate that the through traffic will more than double in ten years after the completion of the waterway, indicating that 20 000 000 tons would be a maximum to be expected after ten years' operation of the waterway.

With an annual commerce of over 35 000 000 tons from the Lakes to the seaboard, the capacity of the waterway would have to be increased over that of the estimate of the Deep Waterway Board, which would materially add to the expense account of construction and maintenance.

The total entrances and clearances of New York Harbor are given by Mr. Corthell as 79 544 653 tons, from which it is evident that the actual export commerce from New York must be considerably less than the registered tonnage shown by the clearances of the port.

A safer estimate can be made by giving the port its proper percentage of the total exports of 29 000 000 gross tons from the entire country in 1899.

It is not fair to argue that because the deepening of the Lake channels from 16 to 21 ft. resulted in reducing freight rates 50%, that a deepening from 21 to 30 ft. will result in a corresponding decrease, for, as before stated, the economical dimensions of a freight carrier in waterways of unlimited depth is a function of the length of haul. The cost of ships, per ton of carrying capacity, increases rapidly with the dimensions of the ship, and the corresponding fixed charges increase faster than the saving in the cost of transport, and, therefore, where terminal detentions are large in comparison with the length of haul, the fixed charges from interest and insurance, in connection with the time of round trip, determine the maximum limit of economical construction.

With the Suez Canal the elements of the problem are entirely different. The vessels passing the canal make trips of several thousand miles, and, since the depth of canal is the controlling element for the entire trip, it will pay to increase the depth to 32.5 ft. with a traffic of only one-third of that of our Lake waterways, where, with a limited length of haul, 21 ft. seems to be an economical maximum depth for waterway improvement.

Referring to Mr. Monro's discussion, the writer by no means wishes to be understood as believing that the Canadian Canals will prove a failure only so far as they may be expected to divert traffic from the present lake and railroad lines, or to materially modify freight rates on such lines.

The Canadian Canals are achievements that their projectors may well be proud of, and in the future, as in the past, will continue to be

Mr. Wisner. important factors in the transportation of Canadian products and manufactures, which are almost certain to largely increase in the near future.

It is well known that barges of 10 ft. draft cannot safely navigate the Great Lakes except during the average quiet weather, and for this reason a barge canal capable of passing vessels of 16 ft. draft, or, say, 18 ft. deep, has been advocated.

Such a canal would shut out all traffic with the seaboard with the modern lake freighters, and, from the longer time required for passing fleets of barges through locks, would not have nearly as great a capacity as a 21-ft. canal. Such a canal would in no way aid in the development of ship construction on the Lakes, and, so far as the writer can see, would not produce any of the indirect benefits to be expected from a deeper waterway with large locks.

Observations to determine the relative speeds of large steamers in deep and shallow water and restricted channels have been continued since the writer's paper was written, with results which practically confirm those obtained by the Board of Engineers on Deep Waterways.

The observed speeds of five steamers running between known points on Lake Huron compared with those on Lake St. Clair, where the depth was only 2 to 3 ft. greater than the draft of the vessel, showed a reduction of speed of 16% in the shallow water. It should be remembered, however, that large steamers, with a speed of 10 miles per hour, run in a sort of trough produced by the motion of the boat and the action of the propeller, so that there is a "squat" of the ship of about 1 ft., making the depth of water beneath the keel that much less than indicated by actual draft of ship and depth of channel.

The observed speeds through the St. Clair Flats Canal and the restricted channels of the St. Mary's River show a little greater average than that obtained by the Board of Engineers on Deep Waterways, and indicate beyond question that 8 miles per hour is a perfectly safe speed in a waterway 21 ft. deep, and having a cross-section of 5 500 sq. ft.

The results of the observations to determine the loss of speed of ships in restricted channels, furnished by Mr. Lionel B. West, are very interesting and practically confirm the results determined and used by the Board of Engineers on Deep Waterways, and made the basis of estimate of speeds in the writer's paper.

John Kennedy, M. Am. Soc. C. E., has kindly furnished the writer with the results of some observations made on the St. Lawrence River to determine the amount that a ship is depressed in a channel when running, which indicates that for ships of 22 ft. draft and speeds of 15 miles per hour, the vessel drops, or "squats," about 1½ ft.

The observations made for the writer on ships in the lake channels

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show a drop of about 1 ft. for a 10-mile speed, which, considering the difference in speed, is a close agreement with the results furnished by Mr. Kennedy, and indicates that a 19-ft. draft is the maximum that can be safely used in a 21-ft. waterway.

Mr. Mayer raises the question whether a waterway with the same area of cross-section as proposed by the Board of Engineers on Deep Waterways, and having a depth of 24 ft., would not be more satisfactory than a 21-ft. waterway.

It is essential for an economical waterway that it should have sufficient depth for the safe passage of the best freight carriers of the routes connected, and a width adequate for the safe passing of vessels without too much loss of time.

To make the depth 24 ft. would diminish the width of channel 30 ft., and make it unsafe for ships to pass each other except at very low speeds. It is difficult to steer vessels when moving slowly, especially with a strong beam wind, and the results of making the channel narrower would be frequent grounding of ships and a much longer time for passage between terminals.

It is noted that in two of the discussions the volume of water needed for the supply of the summit-level of the waterway is erroneously stated, and, in order to clear up any questions as to volume of supply necessary, the following analysis of the problem is submitted:

Let M_1 = Area of lock × lift of the lock west of summit-level;
M_2 = Area of lock × lift of the lock east of summit-level;
D_1 = Displacement of ship going east;
D_2 = " " " " west;
Q = Quantity of water used.

For vessels locking successively over the summit from west to east:

$$Q = M_1 + D_1 + M_2 - D_1 = M_1 + M_2.$$

For vessels locking successively from east to west:

$$Q = M_2 + D_2 + M_1 - D_2 = M_2 + M_1.$$

With vessels alternating regularly each way:

For vessel going east:

$$Q = M_1 + D_1 - D_1 = M_1.$$

For vessel going west:

$$Q = M_2 + D_2 - D_2 = M_2.$$

Average quantity used per vessel $= \dfrac{M_1 + M_2}{2}$.

For an entire season, the alternate lockings will average one-half the total number of lockages, making the supply of water needed one and one-half lockfuls for each ship passing the summit-level.

If the locks at the ends of the summit-level have a less lift than at other points on the waterway, M_1 and M_2 must be computed for the maximum lifts on each side of the summit.

It is interesting to note that, while the displacement of a ship has no

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The recent report of the State Engineer and Surveyor of New York on the Barge Canal from the Hudson River to the Great Lakes gives the estimated cost of a 12-ft. Barge Canal from Troy to Buffalo as $71 600 000, instead of $58 895 000, estimated by the Committee on Canals, in 1899. This increase in the estimated cost of the Barge Canal will increase the fixed charges used in Table No. 3 of the writer's paper, and make the rate per ton for transport of wheat from Chicago to New York $1.42, instead of $1.39, as given in Table No. 3. From Table No. 4 the cost of transport with a 21-ft. waterway is found to be $1.09; and, using the new estimate given by the State Engineer and Surveyor for the completion of the 9-ft. project of 1895, it is found that the cost of transport from Chicago to New York with a 9-ft. Barge Canal will be $1.47.

The present average cost to transport a ton of grain from Chicago to New York by lake and Erie Canal line is $1.75, and by lake and rail line $2.25.

These different rates of transport, with the fixed charges which will be necessary to cover the maintenance, operation and interest on the cost of the routes, fix the volume of traffic which will be necessary to make the proposed routes more economical than existing lines of transportation.

The rates of $1.09, $1.42 and $1.47, for 21-ft., 12-ft. and 9-ft. waterways, are computed on the assumption that the traffic on the waterways annually will be 20 000 000 tons, 15 000 000 tons and 10 000 000 tons, respectively.

In order that the transport rates on the proposed waterways shall be as economical as over existing lines, the traffic would have to exceed 8 000 000 tons, 6 000 000 tons and 4 000 000 tons, respectively, on the 21-ft., 12-ft. and 9-ft. waterways, to enable making the rate as low as the present rate by lake and canal; and 6 000 000 tons, 3 000 000 tons and 2 000 000 tons, respectively, to make the rate as low as the present average rate by lake and rail.

The total traffic on the Erie Canal in 1899 was 2 419 000 tons, of which only about one-half was through freight.

With waterways only 9 ft. and 12 ft. deep, requiring transfer delays and charges at Buffalo, and competing with the existing 14-ft. Canadian Canals, which will likely be increased to a depth of 21 ft. in the near future, it is extremely improbable that the through traffic which would be developed would warrant any better rates than those over existing lines.

With a 21-ft. waterway, allowing through bills of lading between

the lake ports and the seaboard, and quick passage for the economical type of freight carrier for the lake business, a commerce of 8 000 000 tons annually would certainly be available by the time the waterway could be completed, and would probably reach double that volume in a very few years. Mr. Wisner.

The papers and discussions of the proposed waterways have thus far been confined to routes between Lake Erie and the Hudson River. If, however, the question be put on the broader basis of the best and most economical route between the Atlantic and the ports of the entire country tributary to the Great Lakes, whether belonging to the United States or Canada, it is probable that an entirely different route from either of those under consideration would have the preference.

From Sault Ste. Marie to the head of ocean navigation on the St. Lawrence, at Montreal, through Georgian Bay, French River, Lake Nipissing and the Ottawa River is only 615 miles, or 25 miles farther than from The Sault to Buffalo by the lake route. The Ottawa route would have only about 30 miles of restricted canal section on the entire line, and could be constructed for less than three-fourths of the cost of a 12-ft. barge canal between Buffalo and the Hudson River.

A waterway from Montreal to New York for the distribution of domestic commerce could be constructed for about $100 000 000, or over $60 000 000 less for the entire waterway from The Sault than a similar waterway would cost from Lake Erie to New York.

The distance from Sault Ste. Marie to New York by the Canadian route would be about 100 miles less than by the routes from Lake Erie to the Hudson River, making a saving in distance of about 200 miles on each round trip between upper lake ports and New York.

The distance from upper lake ports to Liverpool would be about 800 miles less by the Ottawa route than by Lake Erie and a waterway through New York State.

There is a strong probability that a 21-ft. waterway will be constructed from Georgian Bay to Montreal in the near future, and, unless the people of New York take steps to open up deep water communication with the lake ports, either by a deep waterway to Lake Erie, or to connect with the Ottawa route at Montreal, the St. Lawrence River will become the outlet for the commerce between lake ports and the Atlantic.